Yakima River Basin Integrated Water Resource Management Plan

Economic Analyses of the Proposed Kachess Drought Relief Pumping Plant

Consistent with the *Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies*

FINAL DRAFT

U.S. Bureau of Reclamation

Contract No. R13PC10006 ID/IQ

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Bureau of Reclamation
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Department of Ecology
Office of Columbia River

April 2015

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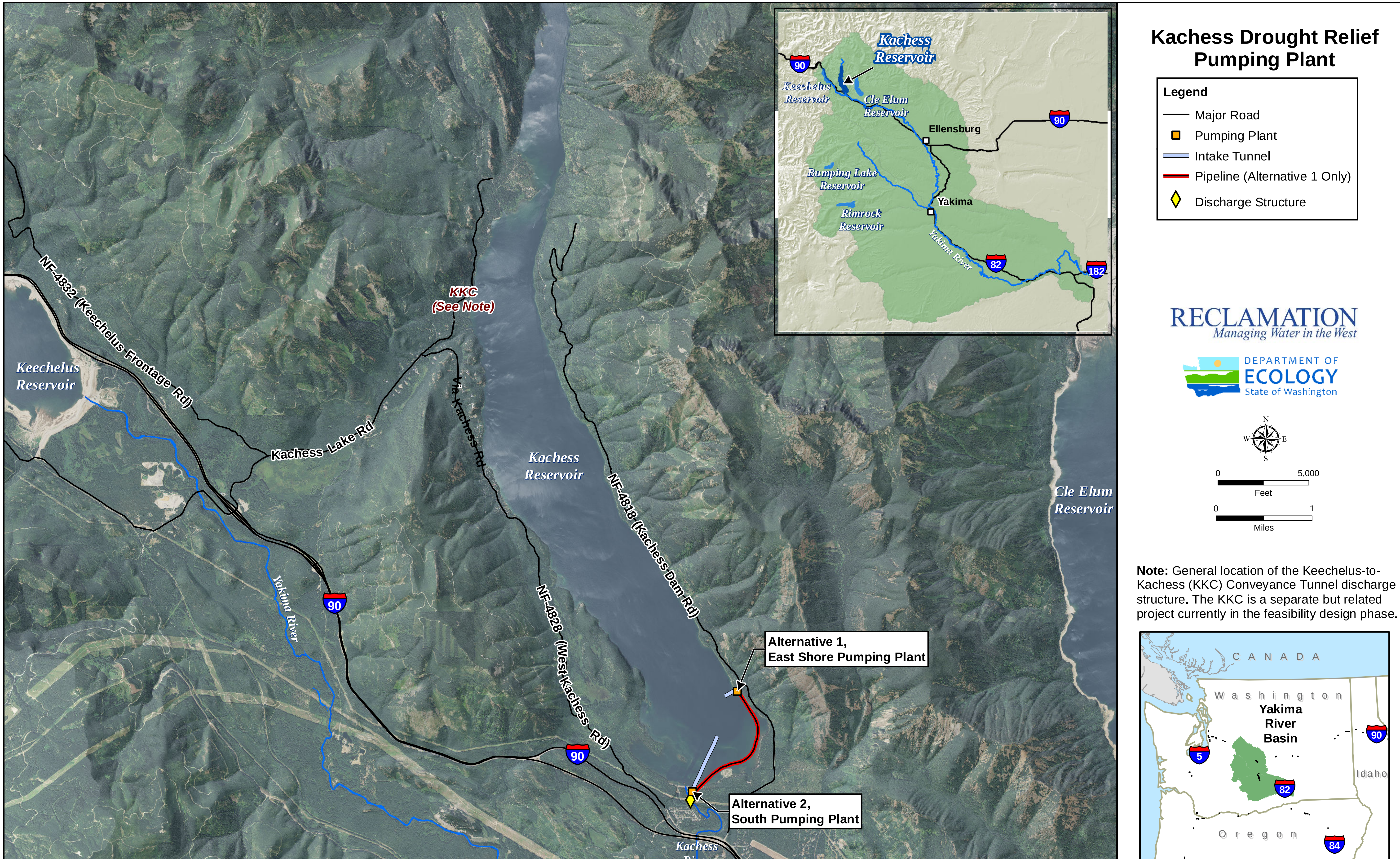
Kachess Drought Relief Pumping Plant
Legend
Major Road
Pumping Plant
Intake Tunnel
Pipeline (Alternative 1 Only)
Discharge Structure
RECLAMATION
Managing Water in the West
DEPARTMENT OF ECOLOGY
State of Washington
0
5,000
Feet
0
1
Miles
Note: General location of the Keechelus-to-Kachess (KKC) Conveyance Tunnel discharge structure. The KKC is a separate but related project currently in the feasibility design phase.
NF-4832 (Keechelus Frontage Rd)
Keechelus Reservoir
Kachess Lake Rd
Via Kachess Rd
KKC (See Note)
Kachess Reservoir
NF-4818 (Kachess Dam Rd)
NF-4828 (West Kachess Rd)
Yakima River
90
Alternative 1, East Shore Pumping Plant
Alternative 2, South Pumping Plant
Kachess River
Cle Elum Reservoir
Kachess Reservoir
Keechelus Reservoir
Cle Elum Reservoir
Ellensburg
Bumping Lake Reservoir
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List of Terms and Acronyms

BTE	Bull Trout Enhancement
EIS	Environmental Impact Statement
IMPLAN®	IMpact Analysis for PLANning modeling software
Integrated Plan	Yakima River Basin Integrated Water Resource Management Plan
KDRPP	Kachess Drought Relief Pumping Plant
KKC	Keechelus-to-Kachess Conveyance
MCR steelhead	Mid-Columbia-River steelhead
NED	National Economic Development Account
OMR&P	operations, maintenance, replacement, and power
Principles and Guidelines	1983 Federal *Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies*
RED	Regional Economic Development Account
redd	A depression in a river bed or lake bed dug by fish to deposit eggs
YakRW	Reclamation’s RiverWare® model for the Yakima River basin

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1.0 Introduction and Summary

This report evaluates one component of the Yakima River Basin Integrated Water Resource Management Plan (Integrated Plan): the Kachess Drought Relief Pumping Plant (KDRPP). The U.S. Department of the Interior Bureau of Reclamation and Washington State Department of Ecology (Ecology) are partners in this project. The goals of the Integrated Plan are as follows: to protect, mitigate, and enhance fish and wildlife habitat; to provide increased operational flexibility to manage instream flows to meet ecological objectives; and to improve the reliability of the water supply for irrigation, municipal supply, and domestic uses (Reclamation and Ecology, 2012a). Figure 1 and Figure 2 show the location of the KDRPP as well as the separate but related Keechelus Reservoir-to-Kachess Reservoir Conveyance (KKC). A separate report titled *Economic Analyses of Proposed Keechelus Reservoir-to-Kachess Reservoir Conveyance Project* (Ecology and Reclamation, 2015b) focuses on the KKC.

Reclamation and Ecology would implement Bull Trout Enhancement (BTE) as an element of the KDRPP in Kachess and Keechelus Reservoirs, as well as elsewhere in the Yakima River basin, to help meet the goals of the Integrated Plan. Therefore, this report includes information on BTE.

1.1 Project Overview

The KDRPP would involve construction of a pumping plant at Kachess Reservoir with an intake located in the reservoir about 80 feet lower than the current outlet. This would provide access to an additional 200,000 acre-feet of water during droughts. Reclamation cannot use this water currently because it is below the existing dam outlet works. Reclamation would release the water pumped from the reservoir into the Kachess River adjacent to the existing dam outlet works. From there, the water would flow approximately 1 mile downstream to Lake Easton and the Yakima River.

Reclamation and Ecology are evaluating two alternatives:

1. East Shore Pumping Plant
2. South Pumping Plant

While the construction techniques and facility configuration would be different for the two alternatives, the facility operations would be similar. See Reclamation and Ecology 2015c, 2015d, and 2015e for details on the two alternatives and their costs.

Although this report focuses on the KDRPP, it also discusses the KKC because of important interactions between the two projects that affect the economic outcomes of the KDRPP. The KKC would be a tunnel starting at a point on the Yakima River just downstream from Keechelus Reservoir and ending at Kachess Reservoir. Reclamation would use the tunnel to transfer water from the Keechelus Reservoir basin into Kachess Reservoir. This would enable Reclamation to improve flow management for fish habitat in the upper Yakima River, and to shorten the time it would take to refill Kachess Reservoir after using the KDRPP in drought years. Reclamation's operation of the KKC in conjunction with the KDRPP would generally maintain the reservoir pool in Kachess Reservoir at higher levels than if the KKC were not constructed. Reclamation is evaluating two alternatives for the KKC tunnel location and configuration: a North Tunnel Alternative and a South Tunnel Alternative.

Reclamation and Ecology 2014 describes BTE. The two agencies would implement the entire BTE program with either the KDRPP alone, the KKC alone, or the KDRPP and KKC together. Bull trout are federally listed as threatened. BTE would address a need for improving the resiliency of bull trout populations in the Keechelus and Kachess watersheds. BTE combined with the KKC, or with the KDRPP, or both, would provide a net positive benefit to bull trout populations in the Yakima River basin.

1.2 Relationship of the KDRPP to the Full Integrated Plan

The Integrated Plan is a comprehensive approach to managing water resources and ecosystem restoration improvements, responding to recurring droughts in the Yakima River basin and the risk of climate change. Reclamation and Ecology developed the Integrated Plan in 2011 in collaboration with the Yakama Nation, irrigation districts, environmental groups, other Federal agencies, the State of Washington, and local governments. The Integrated Plan addresses seven elements: reservoir fish passage, structural and operational changes to existing facilities, surface water storage, groundwater storage, habitat/watershed protection and enhancement, enhanced water conservation, and market reallocation. As a whole, the Integrated Plan would benefit fish and irrigation and offer a synergy that would otherwise be unattainable without the plan.

Reclamation and Ecology estimate the total cost for implementing the Integrated Plan at $3 to $5 billion (plus annual operation and maintenance costs estimated at $10 million), and anticipate its implementation over 30 years.

Reclamation and Ecology would implement the Integrated Plan in phases, using a balanced approach. A "balanced approach" means that during each phase, Reclamation and Ecology would advance activities representing the full spectrum of Integrated Plan components (e.g., storage, fish passage, water conservation, habitat restoration, etc.). Concurrent implementation of balanced elements provides the best opportunity to achieve synergistic benefits of the Integrated Plan for ecosystem improvement and water supply

In March 2014, Reclamation and Ecology identified an Initial Development Phase, covering the first ten-year period (2013-2023). It would advance all seven plan elements and would represent approximately one-quarter of the estimated plan cost (about $900 million). The Initial Development Phase would include implementation of Cle Elum Fish Passage, Cle Elum Pool Raise, Kachess Drought Relief Pumping Plant, and Keechelus-to-Kachess Conveyance; and components associated with each element of the Integrated Plan, such as habitat restoration, agricultural conservation, and groundwater recharge. The Initial Development Phase would also supplement a $99 million acquisition of watershed lands under the Integrated Plan, executed in 2013 by the State of Washington in the Teanaway River subbasin (the Teanaway River flows into the Yakima River).

Reclamation and Ecology recognize that if the Integrated Plan were separated into pieces, economic analysis of the pieces would not result in all components showing positive benefit-to-cost ratios by themselves. However, the Federal *Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies* (*Principles* *and Guidelines*) (Water Resources Council, 1983) indicate that components should be analyzed individually. That is the purpose of this report.

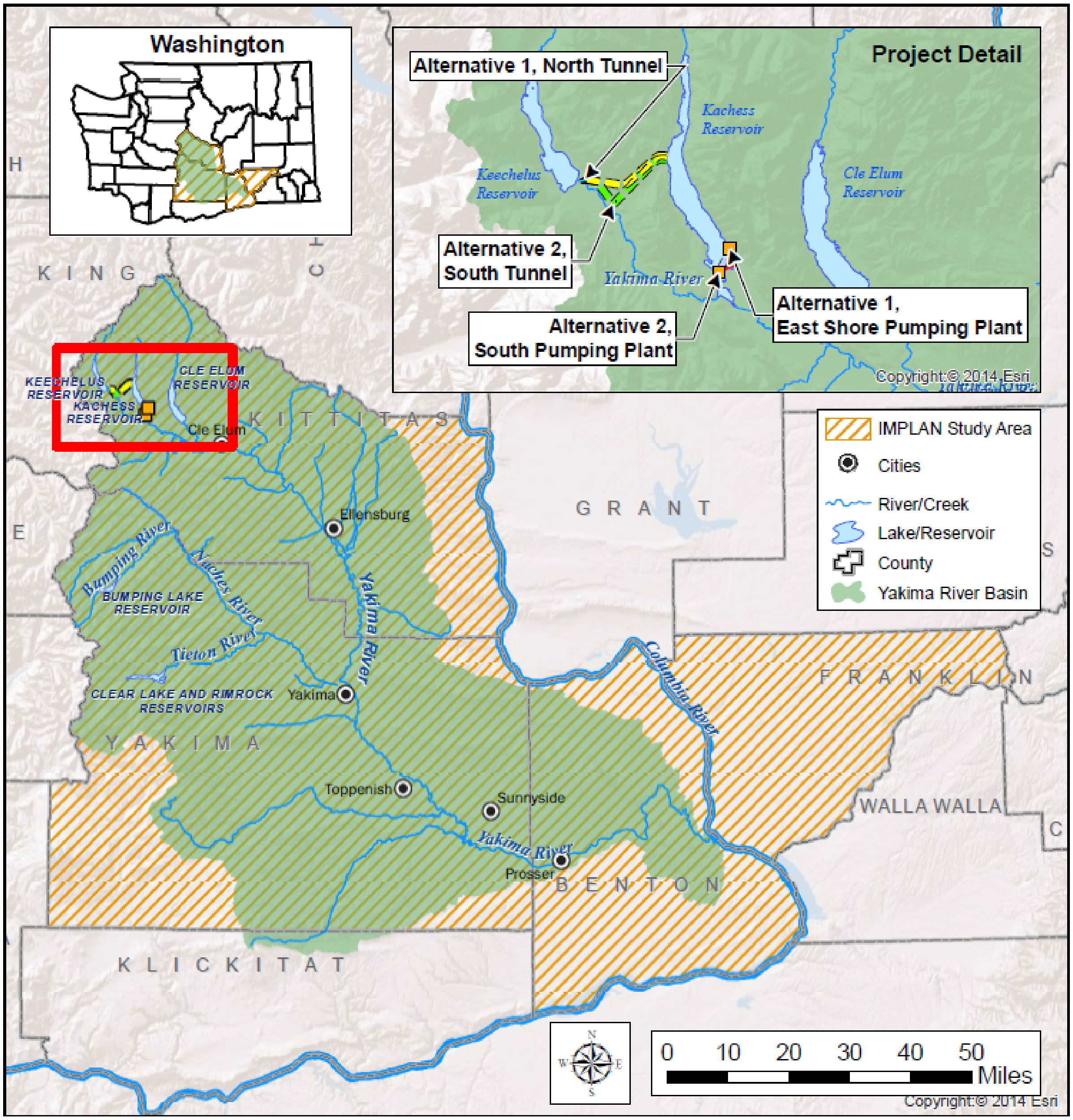
Reclamation and Ecology issued a Four Accounts analysis of the Integrated Plan at full build out (30-year costs) in 2012. That report tabulated the combined benefits and costs of the full suite of Integrated Plan projects and programs. Analyzed as a whole, the Integrated Plan yields a highly favorable benefit-to-cost ratio ranging from 1.4 to 3.2. The costs of the KDRPP represent approximately 11 percent of the total cost of the Integrated Plan. The quantified benefits of the KDRPP represent slightly less than 3 percent of the total quantified benefits of the Integrated Plan if Reclamation and Ecology do not consider the effects of climate change. This rises to 4 percent if the agencies do consider the effects of climate change.

1.3 Methodology Overview

This economic analysis uses the "Four Accounts" framework specified in the *Principles and Guidelines* (Water Resources Council, 1983).[1] The four accounts are National Economic Development (NED), Regional Economic Development (RED), Environmental Quality (EQ), and Other Social Effects (OSE). This report builds on the Four Accounts analysis of the entire Integrated Plan, completed in October 2012 (Reclamation and Ecology, 2012b). That analysis described the economic effects of the Integrated Plan in the aggregate. It did not assess the effects of specific projects included in the Integrated Plan. For the current NED and RED analysis, ECONorthwest applied the economic models and data developed for the overall plan to the fullest extent appropriate for the individual project analyses, using updated information on the projects and adjustment to 2014 dollars.

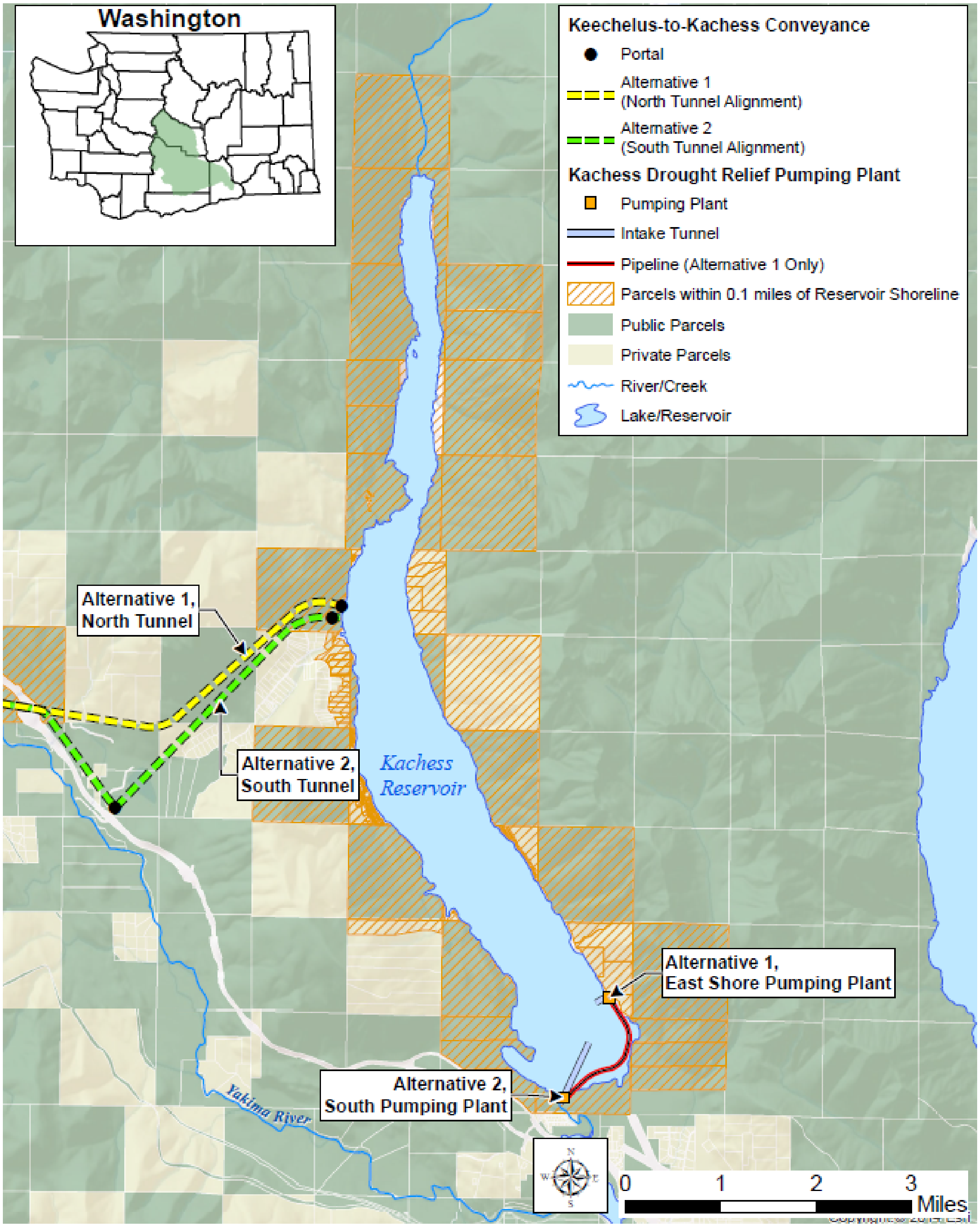
A team that included staff from Reclamation and Ecology and environmental firms consulting to the agencies conducted the EQ and OSE evaluations. All members of the team had worked on the KDRPP and KKC Draft Environmental Impact Statement (EIS) (Reclamation and Ecology, 2015d) and have expertise in environmental analysis, engineering, and Yakima Project operations. The agencies held a workshop to develop the EQ and OSE evaluations. Participants applied their subject area expertise, experience, and knowledge of the project and project area in their evaluations. All decisions made during the workshops used group consensus. Reclamation and Ecology reviewed the evaluation with technical experts from Federal and State resource agencies, the Yakama Nation, and Yakima River basin irrigation districts to receive additional input on the evaluations.

[1] Although the Council on Environmental Quality updated the *Principles and Guidelines* in 2013, these updates will not take effect until agency-specific guidelines are prepared and accepted. For the U.S. Department of the Interior, this will start in June 2015.



Source: ECONorthwest
Note: The IMPLAN® study area includes the entire counties indicated (including area underlying watershed boundary).

Figure 1. Vicinity of the KDRPP and KKC Projects



Source: ECONorthwest. NOTE: Facility locations are approximate.

Figure 2. Land Ownership Surrounding the KDRPP and KKC Projects

1.4 Summary of NED Findings

The KDRPP would improve water availability to prorationed water users under drought conditions. Via increased net farm earnings, this would provide benefits amounting to $214 million in present value (discounted) over 100 years, and $315 million under future adverse climate change conditions (Table 1). Combined with the KKC, these benefits would increase to $248 million and $432 million, respectively. Municipal water supply benefits to the Cities of Yakima and Ellensburg due to reduced prorationing would be approximately $927,000 over 100 years under historical conditions, and $1.4 million under adverse climate change conditions.

Table 1 shows estimated 100-year costs and benefits for the KDRPP in discounted, NPV terms (the table shows costs as negative values, to contrast with benefits). The table presents values both with and without climate change. Construction, operation, maintenance, and equipment replacement costs over 100 years for the KDRPP are $446 million in present value for the East Shore Pumping Plant Alternative and $437 million in present value for the South Pumping Plant Alternative. Lower pool levels for Kachess Reservoir could reduce recreational opportunities by an estimated $4 to $75 million, or $3 to $53 million when combined with the KKC, in total over the 100-year timeframe. The resulting net present value of quantified benefits and costs is -$137 to -$269 million for the South Pumping Plant Alternative and -$128 to -$260 million for the East Shore Pumping Plant Alternative.

Table 1. Net Present Value of Benefits and Costs of the KDRPP Over 100 Years

	KDRPP ($M)	KDRPP with Climate Change ($M)
Agriculture Water Supply Benefits	214	315
Municipal Water Supply Benefits	0.9	1.4
East Shore Construction, Operation and Maintenance Costs	-446	-446
South Construction, Operation and Maintenance Costs	-437	-437
Lost Recreation Due to Reduced Pool Levels	-4- to -38	-8 to -75
Net Present Value, East Shore Pumping Plant	-235 to -269	-137 to -204
Net Present Value, South Pumping Plant	-226 to -260	-129 to -195
BTE Benefits	Not quantified	Not quantified
BTE Costs	-6.7 to -13.3	-6.7 to -13.3

Note: Values discounted at 3.375 percent per year. In the cost category, only long-term operations, maintenance, replacement, and power costs (OMR&P) are discounted. The initial investment costs (field costs, interest during construction, and non-contract costs) are not discounted. All benefits are discounted as they would accrue after construction is completed.

The values shown in Table 1 do not include additional, unquantified costs and benefits. Table 2 lists these costs and benefits.

Table 2. Unquantified Benefits and Costs of the KDRPP

Unquantified Benefits	Unquantified Costs
As an element of the overall Integrated Plan, Reclamation and Ecology expect the KDRPP to reduce conflict over management of water resources and fisheries in the Yakima River basin, reduce potential for litigation, and improve certainty for stakeholders. Availability of additional storage in Kachess Reservoir would enable Reclamation to manage other reservoirs less conservatively to maximize overall fisheries and water supply benefits. Increased flexibility of Yakima Project operations enabled by the KDRPP and other projects may provide other undefined benefits for fisheries and water supply, and greater opportunities to employ market-based transactions to allocate water among uses. In establishing the 50,000-acre Teanaway Community Forest in the Yakima River basin headwaters area in 2013, the State Legislature established a linkage between that forest and the KDRPP. If a water-supply milestone of 214,000 acre-feet of new supply is not achieved by June 30, 2025, the TCF could revert to the State's common school trust, meaning that special provisions for watershed protection, recreation, and habitat protection and enhancement would no longer apply to these forested lands. The KDRPP would provide nearly all of the water required to achieve the milestone, and appears to be the only water-supply project of this magnitude that could be viable for approval, funding, and construction by this deadline. The agencies would implement BTE only if the KKC or the KDRPP were implemented. The BTE would provide benefits to listed bull trout by improving access to reservoir tributaries for spawning, improving nutrient availability, and improving genetic diversity.	Potential reductions in value of private properties used for residences or vacation homes on the shoreline of Kachess Reservoir. Travel restrictions, noise, and other construction impacts on local residents near the Kachess Reservoir, during the four-year construction period for the KDRPP.

Readers should consider the results shown in Table 1 and Table 2 in the context of the full Integrated Plan, and more particularly the Initial Development Phase. Table 3 shows the estimated costs and benefits of the Initial Development Phase as a whole. Even without all of the benefits quantified, the overall benefits of this phase substantially outweigh the overall costs.

Table 3. Net Present Value Benefits and Costs of Initial Development Phase

Project	Costs	Benefits
Cle Elum Fish Passage	$130M[1]	$1,300M to 1,900M
KDRPP	$437M to $446M	$215 to $317M
KKC (incremental with KDRPP)	$258M to $291M	$63 to $203M
Bull Trout Enhancement	$13M	Not quantified
Cle Elum Pool Raise	$18M	Not quantified
Habitat Projects	$85M	Not quantified
Water Conservation Projects	$70M	Not quantified

[1] Costs of Cle Elum Fish Passage and Cle Elum Pool Raise are not discounted.

1.5 Summary of RED Findings

The estimated economic impacts of construction of the KDRPP, the East Shore Pumping Plant Alternative, would be 1,781 job-years within the four-county local region (Table 4) and 3,034 job-years for the State of Washington as a whole. This includes $97 million in personal income in the four-county region and $155 million at the State level. The corresponding job-years for the South Pumping Plant Alternative would be 1,774 job-years in the four-county region and 3,022 job-years at the State level. Personal income under the South Pumping Plant Alternative construction would be $96.6 million in the four-county region, and $154 million for the State as a whole. In addition, the KDRPP would require 6 annual job-years through operation and maintenance for the State as a whole.

The Bull Trout Enhancement Plan would generate 59 job-years in the four-county region, and 98 job-years in total for the State as a whole. It would also generate $3.2 million in personal income locally, and $5 million for the State as a whole.

Increases in agricultural activity provided by the KDRPP alone would require 1,293 local job-years during drought years under historical conditions, and 1,223 job-years under adverse climate change. Under historical conditions, droughts are projected to occur during 16.7 percent of years, while under adverse climate change conditions they are projected to occur during 49.4 percent of years. There would be an additional 59 job-years in the rest of Washington, and 55 job-years under the 2 corresponding conditions. The total agricultural economic output increase under historical conditions for the four-county region would be $172 million, and $162 million under adverse climate change conditions during drought years.

Table 4. Economic Impacts of the KDRPP in the Four-County Region

	CONSTRUCTION	ANNUAL
KDRPP	Full Construction Period	Average Year – Operation
Output	$266 million to $267 million	$637,700 to $703,100
Personal Income	$97 million	$204,000 to $224,900
Job Years	1,174 to 1,781	5
Bull Trout Enhancement Plan	Full Construction Period	
Output	$9 million	N/A
Personal Income	$3.2 million	N/A
Job Years	59	N/A
Additional Agricultural Activity in Drought Years		Average Drought Year
Output	N/A	$162-$172 million
Personal Income	N/A	$42-$44 million
Job Years	N/A	1,223-1,293

Note: Construction impacts are for the full, multi-year construction period (undiscounted) while annual operation impacts are for one average year over the full timeframe. Agricultural impacts are for an average drought year.

1.6 Summary of EQ Findings

Results of the EQ analysis suggest that under the No Action Alternative, conditions for most resources would stay the same or decline. The KDRPP alternatives would cause positive impacts to water supply and bull trout and would increase adaptability to climate change. Under the KDRPP alternatives, most other resources considered in the EQ analysis would experience negative impacts, especially reservoir recreation, cultural, and archaeological resources.

1.7 Summary of OSE Findings

Results of the OSE analysis suggest that the KDRPP alternatives provide positive impacts to long-term productivity, but minor negative impacts from increased energy use and construction worker impacts.

2.0 Methodology

The Federal *Principles and Guidelines* include the following definition of the Federal objective: "to contribute to national economic development consistent with protecting the Nation's environment, pursuant to national environmental statutes, applicable executive orders, and other Federal planning requirements" (Water Resources Council, 1983). The *Principles and Guidelines* establish four main accounts for organizing, displaying, and analyzing project alternatives: NED, RED, EQ, and OSE. NED measures the benefits and costs to the Nation, rather than to the region directly addressed by the Integrated Plan. NED benefits are increases in the total value of the national output of goods and services expressed in monetary units. They include increases in the net value of those goods and services that are marketed and those that are not marketed. NED costs are the opportunity costs of resources used in implementing the Integrated Plan. Opportunity costs could reflect decreases in output or employment losses resulting from the Integrated Plan.

The NED analysis reported here for the Integrated Plan quantifies two categories of economic benefits: increases in the reliability of irrigation water during severe drought years and improvements in municipal and domestic water supply. The computation of the different categories of benefits used analytical methods consistent with the *Principles and Guidelines*.

The RED analysis addresses market impacts due to project construction and operation, BTE construction, and agriculture production attributable to improved water supply reliability. RED focuses on local changes in the quality and quantity of goods and services in terms of market production, employment, and income.

New, agency-specific guidelines are currently being prepared based on the Water Resources Development Act of 2007 (Section 2031) updates. The Federal objective specifies that Federal water resources investments shall reflect national priorities, encourage economic development, and protect the environment by the following methods:

- Seeking to maximize sustainable economic development

- Seeking to avoid the unwise use of floodplains and flood-prone areas and minimizing adverse impacts and vulnerabilities in any case in which a floodplain or flood-prone area must be used
- Protecting and restoring the functions of natural systems and mitigating any unavoidable damage to natural systems

These Federal objectives, when considered in the context of the complex water management challenges addressed by the Integrated Plan and the competing demands for limited Federal resources, mean that Federal investments in water resources should strive to maximize the net public benefits resulting from them. The 1983 *Principles and Guidelines* do not reference the concept of public benefits, but the new *Principles and Guidelines* references them. Reclamation has offered this explanation of the public benefits from water-related investments in the Mid-Pacific Region with regard to economic analyses of Shasta Lake management:

> *Public benefits encompass environmental, economic, and social goals, include monetary and non-monetary effects and allow for the inclusion of quantified and non-quantified measures. …. [I]n addition to traditional, monetized economic development, projects that contribute to Federal ecosystem and species restoration goals are relevant components of water project planning and development. Economic evaluation provides a way to understand and evaluate trade-offs that must be made between alternatives with respect to objectives, investments, and other social goals. It also provides a means to identify the plan that is acceptable, effective, efficient, and complete, and contributes the most favorably to national priorities*. (Reclamation, 2011)

2.1 NED Methodology

The NED account displays changes in the economic value of the national output of goods and services attributable to the individual project. The Federal objective is to contribute to national economic development that is consistent with protecting the Nation's environment. The NED account measures the beneficial and adverse monetary effects of projects and actions in terms of changes in the value of the national output of goods and services. It includes value estimates for project benefits and costs.

2.1.1 Overview of Federal Guidance

The definition of beneficial effects in the NED account include increases in three categories: (1) the economic value of the national output of goods and services from a plan; (2) the value of output resulting from external economies caused by a plan; and (3) the value associated with the use of otherwise unemployed or under-employed labor resources.

Adverse effects in the NED account are the opportunity costs of resources used in implementing a plan. These adverse effects include implementation outlays, associated costs, and other direct costs.

The NED analysis includes the following set of basic assumptions:

- Installation period (the number of years required for installation)
- Installation expenditures (cost incurred for each year of installation)

- Period of analysis (lifespan or time horizon of the project over which benefits and costs occur, which includes installation and a period of time sufficient to capture significant beneficial or adverse effects, not to exceed 100 years)
- Benefit stream (the pattern of benefits that materialize over the period of analysis, calculated in average annual equivalent terms)
- Operation, maintenance, and replacement costs (the pattern of costs that materialize over the period of analysis necessary to maintain the stream of benefits)
- Discount rate (the rate at which both benefits and costs are adjusted)

The following section describes the analysis assumptions.

2.1.2 Assumptions for the NED Analysis

Analytical Approach. The directions outlined in Chapter II of the *Principles and Guidelines* provide methods to estimate each type of benefit and cost included in the KDRPP economic analyses. The quantitative analyses focus on benefits and costs expected to arise from significant project effects. This report analyzes the KDRPP relative to a baseline scenario without climate change, and under adverse climate change conditions. Where relevant, the analyses address interactive effects with the KKC as well.

Installation Period and Installation Expenditures. The NED analysis tailored the installation period to the construction period for each project component and alternative, as detailed in the design information developed by HDR in the feasibility design studies. Expenditures come from the feasibility design study field cost estimates and from noncontract costs (Reclamation and Ecology, 2015d and 2015a). See Section 3.0 for more detailed information by project.

Period of Analysis. The NED analysis considers all projects and effects within a 100-year timeframe that begins when project benefits begin to occur. For the KDRPP, this period begins in the year following completion of construction. Therefore, construction costs occur prior to the 100-year project timeframe.

Benefit Stream. Benefits include improved net farm earnings that are possible because of increased irrigation water supply, and avoided groundwater pumping costs for municipal water supply. See Sections 3.2.1 and 3.2.2 for a discussion of the specific categories of benefits evaluated for each project and alternative.

Operation, Maintenance, Replacement and Power Costs. The proposed projects include operation, maintenance and power costs for the full timeframe, as well as scheduled capital replacement costs based on equipment lifespans. See Sections 3.2.3 and 3.2.4 for a discussion of the specific categories of costs evaluated for each project alternative.

Discount Rate. The NED analysis incorporates a discount rate of 3.375 percent where appropriate, which is the applicable rate that Federal agencies use in the formulation and evaluation of water and related land resources plans in fiscal year 2015, from October 1, 2014 to September 30, 2015 (Reclamation, 2014). Discounting of costs and benefits begins in the first year of the 100-year period of analysis, which for the KDRPP is the first year after completion of construction.

2.1.3 Challenges and Solutions to Address Independent Project Effects

To quantify the benefits and costs of the KDRPP consistent with the guidelines and assumptions outlined above for the NED, one must be able to describe the effects of each project separately from the total effects of the seven program elements and related projects and actions that are part of the Integrated Plan. The Integrated Plan, by definition, is an integrated system, with individual projects and actions operating together to produce synergistic effects to achieve the overall goals and objectives of the plan. For example, the water supply benefits provided by the combination of the KKC and the KDRPP are greater than the two projects modeled alone and summed. Consequently, in practice, it is unlikely that Reclamation and Ecology would undertake individual projects without all or at least a subset of the complete system designed to yield a spectrum of benefits. Any analysis of an individual element of the plan in isolation requires careful consideration of several factors:

- Is the project capable of producing effects in isolation, or is the stream of benefits (and costs) dependent on other project elements?
- Is the analysis likely to underestimate or overestimate the full value of any of the effects when analyzed in isolation?
- Is the analysis, when added to independent assessments of other project elements, likely to double-count or exclude specific benefits or costs?

Due to these concerns and requirements for individual project analysis, the analyses in this report do not include water quantity trading benefits attributable to project alternatives. There is a baseline level of trading in this NED analysis under drought conditions identical to that described and applied during the 2012 Four Accounts analyses. However, this report has no benefits of trading attributed to individual project alternatives (same level of trading under baseline and all alternative permutations). Whereas the 2012 Four Accounts analysis considered the whole of the Integrated Plan without any breakdown by individual components, this analysis does break out the individual effects of the KKC and the KDRPP projects. Similarly, there are no water conservation benefits under the Integrated Plan attributed to these project alternatives, although there are water conservation effects on water availability and prorationing incorporated into the baseline water supply.

Water quantity trading is an important part of the Integrated Plan's ability to increase water reliability in the Yakima River basin. None of that benefit is attributed to specific structural projects, but the connectivity, flexibility, redundancy, and insurance the structural network provides is crucial to the physical, operational, and behavioral requirements necessary to support increased trading and the overall efficiency gains that it provides. Trading provides an important share of the overall benefit for water reliability as described in the 2012 Four Accounts analysis. To the extent the KDRPP contributes to this functionality of water trading, these benefits are unquantified, and contribute to an underestimate of the benefits.

There are differences in values of increased water reliability in this analysis compared to the 2012 Four Accounts analysis for a number of reasons. The 2012 Four Accounts analysis used a period of record from 1981 to 2005. A longer period of record used in the current analysis goes from 1926 to 2009. It includes a wider range of water-supply conditions compared with the shorter period of record. Reclamation used the extended period of record because using a longer period of record is generally considered good practice in the field of hydrologic modeling. However, due to climate change considerations, the longer period of record used in this study is not necessarily more representative of current or future conditions, compared with the shorter period of record used previously.

This analysis also expands upon the modeling conducted for agriculture benefits in the Four Accounts analysis, to account for varying levels of drought severity in addition to drought frequency. Section 3.2.1 contains more detail on this approach.

2.2 RED Methodology

The Regional Economic Development (RED) account registers changes in the distribution of regional economic activity that result from each project. Evaluations of regional effects use nationally consistent projections of income, employment, output, and population. This account evaluates the beneficial and adverse impacts of projects and actions on the economy of the affected region, with particular emphasis on income and employment measures. The affected region reflects the geographic area where Reclamation and Ecology expects significant impacts to occur. Measures of impacts include both monetary and nonmonetary terms.

2.2.1 Overview of Federal Guidance

Three measures of the effects of the plan on regional economies are output, income, and employment:

- **Regional Output.** The value of goods and services produced is the broadest measure of economic activity. It is the sum of expenditures, employee income, proprietor income, profits, and taxes.
- **Regional Income.** The positive effects of a plan on a region's income are equal to the sum of the NED benefits that accrue to that region, plus transfers of income to the region from outside the region.
- **Regional Employment.** The positive effects of a plan on regional employment are directly parallel to the positive effects on regional income, so that analysis of regional employment effects uses the same categories and the same conceptual bases as the analysis of positive regional income effects.

The regions used for RED analysis are those regions within which the plan would have particularly significant income and employment effects, described below.

2.2.2 Assumptions for the RED Analysis

Analytical Approach. The RED analysis applies IMPLAN® (IMpact Analysis for PLANning) modeling software to examine the economic impacts of the Integrated Plan across the region. IMPLAN® is an input-output model that utilizes local industry-level data and traces spending associated with a specific project as it moves through the defined impact area. The RED analysis uses IMPLAN® default conditions and other regional economic data to represent the baseline conditions. ECONorthwest used the most-current available IMPLAN® data (2012) in the RED analysis.

Regional Definition. The Yakima River basin defines the region for the analysis. As for the 2012 RED analysis of the Integrated Plan, ECONorthwest used counties of the Yakima River basin (Kittitas, Yakima, and Benton) in addition to Franklin County, which incorporated the entire Kennewick-Richland-Pasco metropolitan area into the analysis (Figure 1). ECONorthwest also identified economic impacts that would occur for the State of Washington as a whole. Although effects associated with implementing these projects would occur outside these counties, for the purposes of the RED analysis, this area adequately captures the regional effects of implementing the projects.

Categories of Impacts. The analysis incorporates the following categories of impacts:

- Spending associated with construction
- Spending associated with operation, maintenance, replacement, and power
- Changes in the value of agricultural production

In addition to the KDRPP, ECONorthwest analyzed spending associated with construction, operation, and maintenance of BTE projects and presented these results separately. This impact analysis does not account for impacts of changes in population potentially attributable to the KDRPP. Although effects analyzed in the NED analysis may result in changes in the value of other goods and services that could affect the level of income and employment in the region (e.g., changes in recreation and property values), existing data are insufficient to include them in the RED modeling using IMPLAN®. There are no long-term changes in population expected to occur because of the KDRPP. The RED also does not account for economic impacts of changes in property value or recreation associated with changes in reservoir levels for Kachess Reservoir. In general, ECONorthwest expects that the displaced recreation expenditures would remain within the four-county region, as other reservoirs such as Cle Elum Reservoir are available, in addition to other outdoor recreational opportunities. Similarly, fish population benefits associated with the KDRPP and the KKC could generate positive recreational and commercial impacts, and these impacts are not quantified either.

Accounting for Local Contributions. RED impacts only capture those that are not paid for by local contributions. In other words, these impacts do not include the local money that is simply transferred from one group to another within the defined region. Reclamation and Ecology assume that, for the KKC, local contributions would pay 25 percent of capital and local sources would pay 100 percent of operating expenses.

Although effects analyzed in the NED analysis may result in changes in the value of other goods and services that could affect the level of income and employment in the region (e.g., changes in recreation and property values), existing data are insufficient to include them in the RED modeling using IMPLAN®. ECONorthwest also analyzed spending associated with construction, operation, and maintenance of BTE Plan projects and presented those results separately.

2.3 EQ and OSE Methodology

A team that included staff from Reclamation, Ecology, and environmental consultants to the agencies conducted the EQ and OSE evaluations. All members of the team had worked on the KDRPP and KKC Draft EIS (Reclamation and Ecology, 2015d) and have expertise in environmental analysis, engineering, and Yakima Project operations. Reclamation and Ecology conducted the EQ and OSE evaluations in a workshop format. Participants applied their subject area expertise, experience, and knowledge of the project and project area in their evaluations. All decisions made during the workshops used group consensus.

The Reclamation and Ecology team met to conduct the initial EQ and OSE evaluation on February 4, 2015. Reclamation and Ecology reviewed the evaluation with technical experts from Federal and Washington State resource agencies, the Yakama Nation, and Yakima River basin irrigation districts to receive additional input on the evaluations.

The Reclamation and Ecology team considered the input of the technical experts; revised resource categories, subcategories, weighting, and scoring; and made final decisions on the EQ and OSE evaluations.

The process used during the EQ and OSE workshops involved five major steps:

1. Identifying environmental resource categories from the Draft EIS that were most important for decision making
2. Prioritizing the resource categories
3. Dividing some resource categories into subcategories to better capture the benefits and impacts of the alternative
4. Weighting the EQ and OSE categories or subcategories
5. Scoring the benefits and impacts of the EQ and OSE categories or subcategories

2.3.1 Overview of Federal Guidance

The *Principles and Guidelines* include criteria for evaluating alternatives based on the EQ and OSE accounts to display the effects of the alternatives. The *Principles and Guidelines* define these accounts as follows:

- **The EQ account** displays nonmonetary effects on significant natural and cultural resources. This account displays the effects on ecological, cultural, and aesthetic attributes of significant natural and cultural resources, which cannot be adequately measured in monetary terms within the NED and RED accounts.
- **The OSE account** registers plan effects from perspectives that are relevant to the planning process, but not reflected in the other three accounts.

2.3.2 EQ Assumptions for the Analysis

Table 5 lists the EQ resource categories selected by the team along with a brief explanation of the resource categories. The Reclamation and Ecology team identified the resource categories that would have the most effect on the purpose and need for the KDRPP and those that the KDRPP would potentially impact the most. The following are the objectives of the KDRPP as identified in the KDRPP and KKC Draft EIS (Reclamation and Ecology, 2015d):

- Access stored water in Kachess Reservoir that is currently unavailable in order to improve water supply during periods of drought, with a goal of approaching not less than 70 percent of proratable water rights whenever feasible.

- Implement the BTE package of aquatic habitat enhancements, and accomplish assessments of current conditions and limiting factors for bull trout populations in the Yakima River basin to improve the effectiveness of future enhancement actions.

The team divided some resource categories into subcategories to allow for more refined evaluation of the benefits and impacts. Table 5 includes these subcategories.

The Draft EIS evaluated other resources, but Reclamation and Ecology did not include them in the EQ evaluation because the evaluation focuses on resources that are most important for decision-making. The agencies did not include vegetation and wetlands in the EQ evaluation because they are committed to mitigating impacts to ensure no net loss to wetlands or vegetation. Although the reservoir drawdown could decrease water levels in drinking water wells around the reservoir, the agencies did not include groundwater in the EQ evaluation because they would develop appropriate mitigation strategies to ensure drinking water would be available.

The Reclamation and Ecology team prioritized the 11 resource categories based on how the resource categories would affect the purpose and need for the KDRPP. The team rated two resource categories that most affect the purpose and need -- water resources and bull trout -- as being of primary priority and gave them a higher weighting. The team rated the other categories as being of secondary priority. Table 6 shows the weights the team assigned to resource categories based on their priorities and scaled so the weights totaled to 1.0.

The team then weighted the EQ subcategories. Similar to the prioritization process, the team assigned weights to subcategories based on the participants' estimation of how the subcategories would meet the purpose and need of the KDRPP and potential impacts on the resources. Within each category, the subcategory weights total 1.0. The team multiplied category weights by the subcategory weights to obtain the final weights for the EQ resources.

Table 6 also presents the weights of the categories and subcategories.

Table 5. EQ Resource Categories

EQ Resource Category	EQ Resource Subcategories	Background
Water resources	Water supply Instream flows	Improved water supply is part of the purpose and need for the KDRPP. As used here, water supply includes the benefits that would occur from improved water supplies that have not been monetized in the NED or RED, such as benefits of a more stabilized economy. Instream flows are included to represent the benefits other than fisheries benefits that accrue from improved streamflows, such as improved water quality, aesthetics, etc.
Bull trout	Food-based prey Habitat Passage	Enhancements to bull trout habitat is part of the purpose and need for the KDRPP. This category includes the subcategories of food-based prey, habitat, and passage that the team considered to be key indicators of improvements to the productivity and function of aquatic habitat conditions for bull trout.
Fish	Fish abundance Fish passage	"Fish abundance" accounts for overall improvements in fish populations, health, and distribution that will occur under the plan. This resource category includes anadromous and resident fish not listed as threatened or endangered under the ESA. "Fish passage" refers to ecosystem benefits of providing fish with access to more habitat.
Surface water quality	Reservoir water quality	Changes in reservoir level could impact reservoir water quality.
Wildlife	Wildlife	Construction could disrupt wildlife species in the area and the proposed action could improve wildlife habitat in some areas.
Other threatened and endangered species	Northern spotted owl MCR steelhead	The northern spotted owl and Mid-Columbia-River (MCR) steelhead are federally listed species that the project could affect.
Visual quality	Visual quality	The increased reservoir drawdown and the KDRPP facilities could change the visual quality at the reservoir.
Land Use	Property or easement acquisition	The project would require acquisition of some real property or easements.
Recreation	Reservoir recreation Changed character of recreation	The increased reservoir drawdown could affect recreation at Kachess Reservoir. The BTE habitat improvements could change the character of recreation at Gold and Cold creeks.
Cultural resources	Cultural and archaeological resources	Construction of the KDRPP facilities and BTE habitat improvements at Gold and Cold creeks could disturb cultural resources.
Climate change	Adaptability to climate change	The KDRPP is included in the Integrated Plan as a project to help meet the Integrated Plan's purpose of anticipating climate change and increasing Reclamation's flexibility in responding to those changes.
Construction impacts	Construction impacts Transportation	Construction could cause temporary impacts, such as increased emissions, fugitive dust, noise, and vibration. Construction vehicles could increase traffic on local roads and Interstate 90.

Table 6. EQ Categories and Rankings

Category	Category Weight	Sub-categories	Subcategory Weight	Final Weight
Water resources	0.3	Water Supply	0.5	0.15
		Instream Flows	0.5	0.15
Bull trout	0.3	Food-based prey	0.33	0.1
		Habitat	0.33	0.1
		Passage	0.33	0.1
Fish	0.04	Fish abundance	0.5	0.02
		Fish passage	0.5	0.02
Surface water quality	0.04	Reservoir water quality	1	0.04
Wildlife	0.04	Wildlife	1	0.04
Other threatened and endangered species	0.04	Northern spotted owl	0.5	0.02
		Mid-Columbia River steelhead	0.5	0.02
Visual quality	0.04	Visual quality	1	0.04
Land use	0.04	Property or easement acquisition	1	0.04
Recreation	0.04	Reservoir recreation	0.5	0.02
		Changed character of recreation	0.5	0.02
Cultural resources	0.04	Cultural and archaeological resources	1	0.04
Climate change	0.04	Adaptability to climate change	1	0.04
Construction impacts	0.04	Construction impacts	0.5	0.02
		Transportation	0.5	0.02
TOTALS	**1.0**			**1.0**

2.3.3 OSE Assumptions for the Analysis

The team identified and prioritized elements of the OSE account. As noted above, the OSE account includes perspectives that are not included in the NED, RED, or EQ accounts. The team identified three resource categories to include in the OSE account -- urban and community impacts, long-term productivity, and energy requirements and energy conservation. The urban and community impacts category includes impacts to local communities caused by large numbers of construction workers. Long-term productivity includes the subcategories of improved fish populations, resilience to climate change, and improved irrigation reliability. These subcategories capture the social benefits of improved fish populations, resilience to climate change, and a more reliable irrigation supply. OSE accounts often include environmental justice, but the team decided not to include that category because the Draft EIS did not identify any potential environmental justice impacts (Reclamation and Ecology, 2015d). Table 7 lists and describes the OSE categories.

Table 7. OSE Resource Categories

OSE Resource Category	OSE Resource Subcategories	Background
Urban and community	Construction worker impacts	This category is included to capture the impacts that would occur in communities surrounding the construction area from the large number of construction workers employed on the project. These impacts include housing demand.
Long-term productivity	Improved fish populations	Long-term productivity includes the nonmonetary and social benefits that accrue from the project. Sub categories include improved fish populations, resilience to climate change, and improved irrigation reliability.
	Resilience to climate change	
	Improved irrigation reliability	
Energy requirements and energy conservation	Increased energy use	This category includes the extent that the KDRPP would increase energy use in the Yakima River basin.

The team weighted the OSE categories and subcategories as shown in Table 8. The team weighted long-term productivity higher than the other OSE resources because of the overall potential to influence social conditions in the Yakima River basin such as improved fish populations, resilience to climate change, and improved irrigation reliability.

Table 8. OSE Categories and Rankings

Category	Category Weight	Sub-categories	Subcategory Weight	Final Weight
Urban and community	0.15	Construction worker impacts	1	0.15
Long-term productivity	0.70	Improved fish populations	0.33	0.23
		Resilience to climate change	0.33	0.23
		Improved irrigation reliability	0.33	0.23
Energy requirements and energy conservation	0.15	Increased energy use	1	0.15
TOTALS	1.0			1.0

2.3.4 EQ and OSE Impact Rating

After the team identified, ranked, and weighted the EQ and OSE resource categories, the team rated the impacts. The EQ and OSE evaluations compared the impacts of the No

Action Alternative and the two action alternatives (the KDRPP East Shore Pumping Plant and the KDRPP South Pumping Plant) as described in the Draft EIS. The team rated the impacts by comparing the impacts of the No Action Alternative and the two action alternatives to the existing baseline conditions.

During the rating process, the Reclamation and Ecology team rated the No Action Alternative based on current Yakima Project operations and the projects and actions identified to occur under the No Action Alternative -- Yakima River Basin Water Enhancement Project Phase II conservation projects, and the Washington State Department of Transportation Interstate 90 Snoqualmie Pass East Phase 2A project. For all alternatives, the team considered impacts and benefits over a 50-year period. The team also considered potential impacts of climate change, changes in vegetation and wildlife, and anticipated development that would occur over the next 50 years for both alternatives.

To compare the effects of the alternatives, the team developed a scale, which accounts for both positive and negative impacts. It also uses a zero rating to indicate no change relative to existing conditions. The scale is listed below:

0 = no change from existing conditions

3 = major positive impact	-3 = major negative impact
2 = moderate positive impact	-2 = moderate negative impact
1 = minor positive impact	-1 = minor negative impact

The team rated the impacts using the same consensus-based approach as the rankings and ratings. To determine the final scores for the EQ and OSE evaluations, the team multiplied the resource category scores for each alternative by the category or subcategory weight. The resulting numbers reflect both the potential significance of the effect and the relative importance of the resource category or subcategory.

3.0 KDRPP Analysis and Findings

This section focuses on the categories of effects and impacts that would be associated with the KDRPP project. It begins with a basic description of the KDRPP project, and then describes analyses and results.

3.1 KDRPP Project and Alternatives

Reclamation and Ecology intend that the KDRPP would involve the construction of an outlet on Kachess Reservoir about 80 feet lower than the current outlet, allowing an additional 200,000 acre-feet of storage to be pumped to increase water supply reliability in a drought. This water would increase dry-year deliveries to proratable water users, which almost entirely serve irrigated agriculture.

By lowering the outlet, the KDRPP would make it possible for reservoir water levels to fall considerably below current levels, potentially for extended periods. This would affect reservoir-access structures (e.g., docks), reservoir-dependent recreational users, and property owners with views of the reservoir. The reservoir would fill more rapidly in wet and average years with the addition of the KKC. The KKC would also shorten the refill period for Kachess Reservoir following drought years.

In the first year of a drought, Reclamation would draw Kachess Reservoir down to the gravity outlet level by about August. The KDRPP would deliver water from below the existing outlet throughout the remainder of the irrigation season. If Reclamation operated the pumping plant continuously every day at the proposed pumping rate of 1,000 cfs, it would take about 101 days to draw down the entire 200,000 acre-feet of stored water that is below the elevation of the existing outlet. In some years that the KDRPP is activated, Reclamation may use all of this volume, while in other years it may use less water. After the irrigation season ends in early October, the reservoir would begin refilling. Section 3.2.4 includes information about expected reservoir levels under operation of the KDRPP.

Reclamation and Ecology are evaluating two alternatives for the KDRPP: *Alternative 2A – KDRPP East Shore Pumping Plant*, and *Alternative 2B – KDRPP South Pumping Plant*. The alternatives primarily differ in location of the pumping plant, but also have differences in infrastructure because of pumping plant designs. Reclamation would operate the KDRPP the same, regardless of the location of the facilities. See Reclamation and Ecology, 2015c for more details on the alignment options and engineering details.

3.1.1 Bull Trout Enhancement

Reclamation and Ecology expect BTE to provide long-term net benefits to the bull trout populations in the Keechelus and Kachess Reservoirs. Populations in both watersheds are listed as threatened under the Endangered Species Act and are some of the smallest populations in the Yakima River basin. Reestablished year-round tributary passage (Gold Creek, Cold Creek, and potentially the upper Kachess River) into the reservoirs is expected to increase the number of spawning fish and redds where they deposit their eggs. Reclamation and Ecology expect this to cause increased population productivity and abundance.

Artificial nutrient enrichment of these watersheds is also included in the BTE program. The agencies expect artificial nutrient enrichment to most directly increase juvenile abundance and provide an improvement in the prey base for sub-adult and adult bull trout residing in the reservoirs. This would also cause an increase in growth, condition factors, and survival rates, which over time would result in an increase in population abundance and productivity. In addition, artificial nutrient enrichment would support the future reintroduction of sockeye into these two reservoirs. If proven feasible, there is the potential to expand the amount of spawning and juvenile rearing habitat in Box Canyon Creek above the first impassable falls by approximately 3 miles, to increase population abundance for the Box Canyon population. Reestablished passage into Cold Creek from the Keechelus Reservoir would open approximately 2.2 miles of habitat that is currently inaccessible.

The implementation of BTE has the potential to accelerate the rate of population recovery greatly in terms of abundance and increased genetic diversity for the Keechelus and Kachess populations by translocation of fish from healthier populations in the Yakima River basin.

Reclamation and Ecology expect these collective actions to increase bull trout abundance, productivity, and genetic diversity for the Keechelus and Kachess populations. Because of these actions, these populations should become more resilient to the natural fluctuation in environmental factors that can negatively impact population abundance and productivity. These actions would also provide a benefit to the overall health of the ecosystem.

This analysis assumes that if either the KKC or the KDRPP were implemented alone, the full BTE costs would be assigned to that project. If both were implemented, half of the BTE costs would be assigned to each.

3.2 NED Analysis

3.2.1 Quantified Benefits

Water Supply for Agriculture

Mechanism of the Effect. The KDRPP would potentially provide agricultural water supply benefits by increasing water availability for proratable users during drought conditions. Proratable users have junior water rights that are satisfied by an equal share among all proratable users, after senior, nonproratable users have received their full allotment (Reclamation and Ecology, 2011). Hydrologic modeling demonstrates how the KDRPP alone changes available water for proratables under drought conditions. The KKC could potentially make the KDRPP more valuable than it would be alone in terms of water made available under drought conditions.

Irrigated agriculture is the largest user of water in the Yakima River basin. The Yakima Irrigation Project (Yakima Project), operated by Reclamation, provides most of the water used for irrigation. The Yakima Project provides water to six irrigation divisions: Roza Irrigation District (Roza), Kittitas Reclamation District (Kittitas), Sunnyside Valley Irrigation District (Sunnyside), Wapato Division (Wapato), Yakima-Tieton Irrigation District (Tieton), and Kennewick Irrigation District (Kennewick). The Integrated Plan would most directly affect the first five in this list. They have approximately 81 percent (1,938,300 acre-feet) of the total, proratable and nonproratable, entitlements (2,406,917 acre-feet) to water in the Yakima, Tieton, and Naches Rivers above the Parker gage (Reclamation and Ecology, 2011).

The amount of land irrigated in the Yakima River basin is limited. Federal law constrains the amount of land served by the Yakima Project, and the available water supply limits the amount of land irrigated outside the Yakima Project. The Yakima Project currently supports irrigation for 383,000 acres (Reclamation and Ecology, 2011). Because of the constraints on irrigated acreage, the Integrated Plan assumes acreage available for irrigated agriculture in the basin would not expand in the future. Furthermore, it aims to improve reliability of irrigation supplies, but not to bring about expansion of irrigated acreage.

The reliability of water supplies for irrigators served by the Yakima Project differs considerably for two groups of irrigators: nonproratable and proratable. Nonproratable water rights are more senior and have priority dates before May 10, 1905. The total water supply available serves these rights first, which Reclamation defines each year based on reservoir storage, runoff forecast, and return flow estimates. Proratable water rights, however, have a priority date of May 10, 1905. When the total water supply available cannot fully serve both groups, it goes first to satisfy the nonproratable water rights insofar as possible, with any remainder shared by the proratable water rights. In each of the droughts occurring in recent decades, Reclamation has been able to supply nonproratable water rights fully, but proratable water rights have received reduced (prorated) supplies, as low as 37 percent of normal supply in 2001. The Integrated Plan aims to improve the reliability of supplies for irrigation users with proratable water rights.

The Parker gage measures flow in the Yakima River downstream of the City of Union Gap. Reclamation and Ecology use this gage as a key control point for water resources in the Yakima River basin. The primary concern for water-supply reliability involves the five irrigation divisions above the Parker gage: Roza, Kittitas, Sunnyside, Wapato, and Tieton. This analysis does not include Kennewick Irrigation District because it has not experienced reduced water availability during past droughts. However, there is some potential for Kennewick to choose to participate in the future. Currently, because of their relative downstream position with respect to the other districts, Kennewick receives sufficient water due to return flows from other districts. If these return flows decline, however, Kennewick may face conditions under which involvement makes sense.

The following discussion refers to each of these entities as a "district." The concern narrows further, to Roza, Kittitas, and Wapato Districts, insofar as Sunnyside and Tieton have stated they do not need additional water during drought periods even though portions of their entitlements are proratable (Reclamation and Ecology, 2011). Table 9 compares the proratable water rights for the three districts with the rest of the Yakima Project entitlements above the Parker gage. Kittitas, Roza, and Wapato Districts hold 82 percent of the total proratable water rights above the Parker gage. They hold 96 percent of the proratable water rights above the Parker gage, exclusive of Sunnyside and Tieton Districts.

Table 9. Proratable Water Rights above Parker Gage

IRRIGATION DISTRICTS	PRORATABLE ENTITLEMENTS (ACRE-FEET)	% OF TOTAL PRORATABLE ENTITLEMENTS	
		Total	Not Including Sunnyside and Tieton
Roza	393,000	30	35
Wapato	350,000	27	31
Kittitas	336,000	26	30
Subtotal	*1,079,000*	*82*	*96*
Sunnyside	157,776	12	0
Tieton	30,425	2	0
Subtotal	*1,267,201*	*97*	*96%*
Nondivision Entitlements	42,874	3	4
Total	1,310,075	100	100

Source: Adapted from Reclamation and Ecology, 2011.

Method of Quantification. The basis of increased water supply value for agriculture is the change in the value of net farm earnings among receiving irrigation districts. Under drought conditions, proratable water users must fallow a portion of their fields. The analysis utilizes a model of farming activity and revenue to compare net farm earnings among the irrigation districts at various levels of prorationing. ECONorthwest developed this model for the 2012 Integrated Plan analysis to quantify the effect of water supply reliability improvements and transfers by considering the difference in production and earnings due to water availability for each alternative scenario and the relevant baseline scenario(s).

Description of Model. Reclamation's RiverWare® model for the Yakima River basin, known as "YakRW," produced hydrologic modeling results for a number of scenarios, including (1) the baseline No Action Alternative, (2) the KKC alone, (3) the KDRPP alone, and (4) the KKC and the KDRPP. In addition, it generated versions of these scenarios under adverse climate change conditions, involving more frequent and severe droughts. This model produces annual shares of water available to proratable users for each scenario, which serves as an input to the economic modeling of agricultural production and value.

The NED analysis includes updated prices and costs from the 2012 model using the most current data available, and reports figures in 2014 dollars. The model computes the direct increase in net farm earnings for irrigators in the Yakima Project who would receive improved reliability of water supplies because of the project. It also identifies gross farm earnings, and distribution of production. Because this analysis does not include any variation in transactions among the alternatives, benefits of increased water availability for a model run are generally proportional to proratable shares by district.

The model addresses variable cost considerations from the farm budget perspective. It includes crop-specific annual variable costs per acre, annual crop-specific yield per acre, and crop prices. See the data section below for these sources. These parameters are consistent with the *Principles and Guidelines* (Section 2.3.5) regarding farm budget analysis.

During an average nondrought year, the model assumes irrigators have all the water they require to satisfy crop irrigation requirements. During drought years, the model assumes historical constraints on proratable water users and the baseline (pre-Integrated Plan) volume of water quantity trading among irrigators. The basis of trading is the reallocation of water from low-value crops to high-value crops, where the measurement of value is annual net farm earnings per acre-foot. The model assumes that accompanying financial transactions take place so that all parties are better than without trading. The model does not track individual acre-feet of water or individual transactions, but rather identifies equilibrium conditions, given constraints. Trading is constrained to a maximum of 30,000 acre-feet of water annually based on discussions with irrigation district representatives for the 2012 Four Accounts analysis, and only intradistrict trading is allowable for Wapato and Tieton. ECONorthwest established these assumptions to represent a baseline for the level and type of trading occurring without the Integrated Plan.

This section describes the data used in the model. The model has three adjustable variables, and three output variables.

Adjustable Variables. The model's three adjustable variables are the following:

1. The degree of the constraint on water supply during a severe drought year (percentage of full entitlement available to proratable irrigators) based upon outputs of the YakRW model.
2. The minimum annual net farm earnings (dollars per acre-foot) for water buyers. This applies to crops receiving water through market-based water reallocation, recognizing that irrigators are unlikely to purchase water during a severe drought to irrigate low-value crops. It is set at $150 for these analyses based on consultations with the irrigation districts (Reclamation and Ecology, 2012b).
3. The maximum volume of interdistrict trading for Roza, Kittitas, and Sunnyside Districts (percent of available water that Reclamation allows traded outside the district). This variable recognizes and avoids the potential adverse impacts on the districts' operations that could occur if trades disrupt normal operating procedures and characteristics through substantial exports. It is set at 90 percent for these analyses, based upon consultations with the irrigation districts.

For the analyses described in this report, there is no variation in allowable quantity of trading among alternatives, including the baseline No Action Alternative.

Output Variables. The model's three output variables include (1) annual net farm earnings, (2) volume of intradistrict trading, and (3) volume of interdistrict trading. The model produces these output variables, at the district level, for each scenario. It also generates crop-specific information by district identifying the predicted, or representative, composition of crop production under a particular scenario.

Description of Data. The spreadsheet model relies on three types of data: (1) data describing the crops grown in the five irrigation districts and the amount of water needed to satisfy each crop's irrigation requirements, (2) proratable and nonproratable entitlements across the five districts, and (3) annual net farm earnings, by crop, across the five districts. The following sections describe each type of data.

Crops and Water Demand. Table 10 identifies the crops used in the model, their distribution across the five districts, and water demand (by crop) in each district. The values in Table 10 rely on data from district-level surveys and the Washington State Department of Agriculture, collected over the past decade, and represent the most recent data available. For the 2012

Integrated Plan, Reclamation communicated with the irrigation districts and other relevant agencies to identify any potential updates to the data. In all cases, no district or agency had updated data for use in the analysis. The model assumes irrigators in each district continue using the same amount of land to produce the same mix of crops every year, and that water demand (in terms of acre-feet per acre, by crop) remains constant into the future. For example, the model assumes that apples grow on 548 acres in the Kittitas Reclamation District and that production requires 5.6 acre-feet of water per acre, both now and in the future.

Table 10. Crops and Water Demand by District

CROP	KITTITAS		ROZA		SUNNYSIDE		TIETON		WAPATO	
	Acres	Acre-feet/Acre	Acres	Acre-feet/Acre	Acres	Acre-feet/Acre	Acres	Acre-feet/Acre	Acres	Acre-feet/Acre
Alfalfa Hay	1,778	4.8	2,878	4.7	12,219	4.8	124	3.1	12,939	5.6
Apples	548	5.6	23,969	5.6	6,720	5.8	17,288	3.7	10,445	7.0
Asparagus	-	-	635	4.2	2,657	4.4	-	-	1,831	5.2
Concord Grapes	-	-	11,913	3.3	20,784	3.8	-	-	4,954	4.7
Hops	-	-	3,540	3.4	10,955	3.7	-	-	15,350	4.3
Mint	-	-	137	4.9	1,770	5.1	-	-	9,424	6.1
Miscellaneous	81	4.7	3,613	3.9	21,050	4.0	355	3.3	24,017	5.0
Other Grain	1,963	4.6	2,670	3.0	3,246	3.2	21	2.1	662	4.0
Other Hay	4,971	5.5	431	4.8	3,719	5.0	1,058	3.2	3,204	6.2
Other Tree Crops	256	5.3	8,797	5.5	9,534	5.8	2,729	3.6	3,211	6.7
Other Vegetables	6	4.1	270	2.5	525	3.0	-	-	3,286	4.1
Pasture	13,129	4.5	62	3.8	1,141	3.7	-	-	1,960	4.8
Potatoes	89	4.3	72	4.2	-	-	-	-	1,161	5.1
Sweet Corn	1,368	3.1	173	3.1	39	2.8	-	-	912	3.3
Timothy Hay	29,607	5.6	-	-	-	-	-	-	126	6.4
Wheat	1,710	4.4	1,333	3.0	2,892	3.2	-	-	15,621	4.0
Wine Grapes	10	3.1	11,998	3.3	1,992	3.8	9	2.1	12	4.7
Total	55,516	N/A	72,491	N/A	99,243	N/A	21,584	N/A	109,115	N/A

Source: Adapted from Washington State Department of Agriculture, 2010; Reclamation and Ecology, 2011.

Entitlements. Existing data describing water entitlements (in terms of acre-feet) provide the basis for estimating the percentage of each district's water supply that is proratable and the percentage that is nonproratable (Reclamation and Ecology, 2011). The model applies these percentages (proratable and nonproratable) to crop acres in each district to distinguish entitlements by crop type. If, for example, 50 percent of a district's water entitlements are proratable, the analysis assumes that 50 percent of the water allotted for each crop in that district is proratable.

Annual Net Farm Earnings. Table 11 summarizes the data used in the model to derive annual net farm earnings. For each crop, the model uses average yield (Scott et al., 2004; Vano et al., 2009), price (U.S. Department of Agriculture, National Agricultural Statistics Service, 2013a, 2013b), and variable cost values (Washington State University Extension, various years; Reclamation, 2008) relevant to the five districts. The model calculated annual net farm earnings per acre by multiplying average yield by average price (to get annual gross farm earnings), then subtracting annual variable cost. There are insufficient data to distinguish between annual net farm earnings associated with different crops grown in different districts, so the model used the same values across the five districts. ECONorthwest adjusted values to 2014 dollars using the commodity-specific producer price index from the U.S. Bureau of Labor Statistics (U.S. Bureau of Labor Statistics, 2014).

Annual net farm earnings ($/acre) from Table 11 are divided by water demand (acre-feet/acre) for each crop in each district (from Table 10) to calculate irrigation-related annual net farm earnings ($/acre-foot). Table 12 summarizes these values.

Table 11. Annual Net Farm Earnings ($/Acre) by Crop

CROP	OUTPUT UNITS	AVERAGE YIELD (UNITS/ACRE)	AVERAGE PRICE ($/UNIT)	ANNUAL VARIABLE COST ($/ACRE)	ANNUAL NET FARM EARNINGS ($/ACRE)
Alfalfa Hay	Tons	5.6	$233	$608	$688
Apples	Tons	16.1	$505	$6,248	$1,859
Asparagus	Cwt	37.2	$92	$2,643	$775
Concord Grapes	Tons	8.6	$275	$602	$1,767
Hops	Pounds	1,976.2	$3	$3,356	$2,726
Mint	Pounds	124.9	$22	$2,084	$615
Miscellaneous	Bushels	200.0	$5	$530	$533
Other Grain	Bushels	141.5	$5	$530	$146
Other Hay	Tons	4.7	$206	$788	$180
Other Tree Crops	Tons	13.6	$1,273	$7,658	$9,660
Other Vegetables	Cwt	500.0	$19	$1,487	$8,008
Pasture	Tons	4.7	$233	$608	$487
Potatoes	Cwt	546.1	$7	$2,107	$1,947
Sweet Corn	Cwt	193.9	$5	$457	$605
Timothy Hay	Tons	3.8	$245	$386	$545
Wheat	Bushels	103.4	$5	$474	$20
Wine Grapes	Tons	4.0	$1,008	$1,319	$2,713

Source: Adapted from Scott, 2012.

Table 12. Net Farm Earnings per Acre-Foot of Water by Crop and Irrigation District

CROP	KITTITAS	ROZA	SUNNYSIDE	TIETON	WAPATO
Alfalfa Hay	$142	$146	$143	$221	$122
Apples	$334	$333	$323	$500	$268
Asparagus	-	$187	$175	-	$150
Concord Grapes	-	$535	$469	-	$376
Hops	-	$811	$731	-	$638
Mint	-	$127	$120	-	$100
Miscellaneous	$114	$137	$132	$160	$107
Other Grain	$32	$49	$46	$69	$37
Other Hay	$33	$37	$36	$56	$29
Other Tree Crops	$1,826	$1,756	$1,680	$2,706	$1,453
Other Vegetables	$1,934	$3,242	$2,669	-	$1,953
Pasture	$109	$130	$131	-	$101
Potatoes	$452	$461	-	-	$385
Sweet Corn	$193	$196	$213	-	$182
Timothy Hay	$98	-	-	-	$85
Wheat	$4	$7	$6	-	$5
Wine Grapes	$889	$822	$720	$1,311	$577

Source: Adapted from previous tables.

Model Limitations. The model does not account for several market and behavioral factors likely to occur for agriculture under actual long-term drought conditions in the Yakima River basin. The model does not account for adaptation to drought through shifting to more drought-tolerant crops, which would likely reduce the marginal benefit of increased water supply reliability. Conversely, the model does not capture the importance of maintaining irrigation for vegetation that must survive for multiple years, such as tree crops and perennial grasses. In this way, avoiding loss of capacity to irrigate these crops would increase the value of increased water supply reliability.

Input costs and market prices for output could respond to changes in production, and the model does not estimate these dynamics either. Reduced production under drought conditions would increase prices if there were any price response, due to increased scarcity, at least locally. Reduced production would locally reduce demand for inputs, which would lower production costs if there were any input price response. Both of these forces would reduce the magnitude of the effect of increased water supply reliability on net farm earnings. Investigations into correlations between crop prices and water availability showed little relationship locally, suggesting dominant market forces are either nonlocal or not water related (Reclamation and Ecology, 2012b).

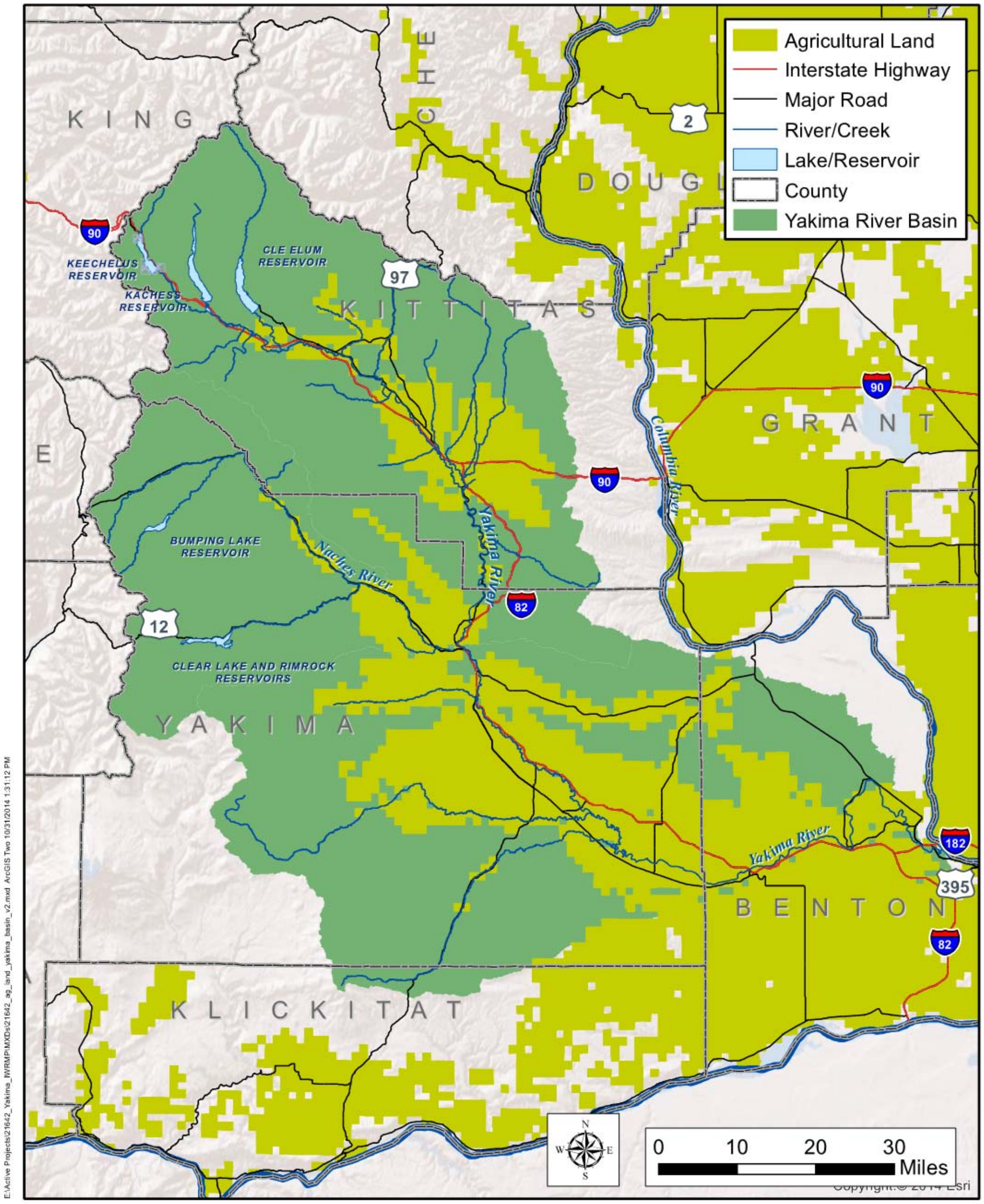
While these exclusions from the model work in opposing directions, it is unclear which forces would be more important, and how actual effects on agriculture would occur. In general, the model does capture the primary forces driving net farm earnings, namely overall levels of production, particularly for high value crops.

One adaptation strategy would be reduced application of water on crops, thereby reducing production but not fallowing. For example, a farmer might take an allocation sufficient to fully irrigate 100 acres, and use it to provide 50 percent of typical irrigation volumes to 200 acres. Current irrigation monitoring in the Yakima River basin involves assessment of whether an acre is irrigated, rather than the quantity of water, according to irrigation district staff. It does not include metering that would allow an irrigator to reduce water use on multiple acres rather than fallowing a subset.[1] Therefore, the model does not capture the effects on production of reduced watering for a given acre, as there currently is no incentive for such water use conservation efforts.

The model does not account for potential crop switching to adapt to drought conditions. It is unlikely, given contracts and preparation requirements, that farmers could change growing plans in response to an individual season's drought. However, in the long-term, if drought conditions become more frequent and severe, and water scarcity increases, it is likely that farmers would choose crops that require less water or generate greater returns per acre-foot of water. This adaptation over the long-term would lessen the severity of adverse effects imposed by drought conditions.

The model does not account for potential variation in variable cost across irrigation districts other than water requirements. The water requirements vary by district in some cases because of different function and design of conveyance and irrigation. For example, proportions of diversion to consumption vary in some cases by district. There is no evidence that other variable costs vary systematically by district, and would vary in correlation to water availability differences across alternatives. If marginal returns to irrigation water vary more greatly in reality than specified in the model, gains from trading might be greater than represented. But, this would depend on how that variation aligns with proratable versus non-proratable rights, and which districts. If the lack of this information were to dictate that the model show no variation in crop-specific water demand by district, there would be substantially less variation across crop-acre units in the model, and consequently less opportunity to calculate likely benefits of water trading.

[1]Metering, as with residential water consumption, could allow allocation by volume of water, rather than acre of irrigation. In this way, there would be greater incentive for conservation techniques, or reduced per-acre volumes during droughts.



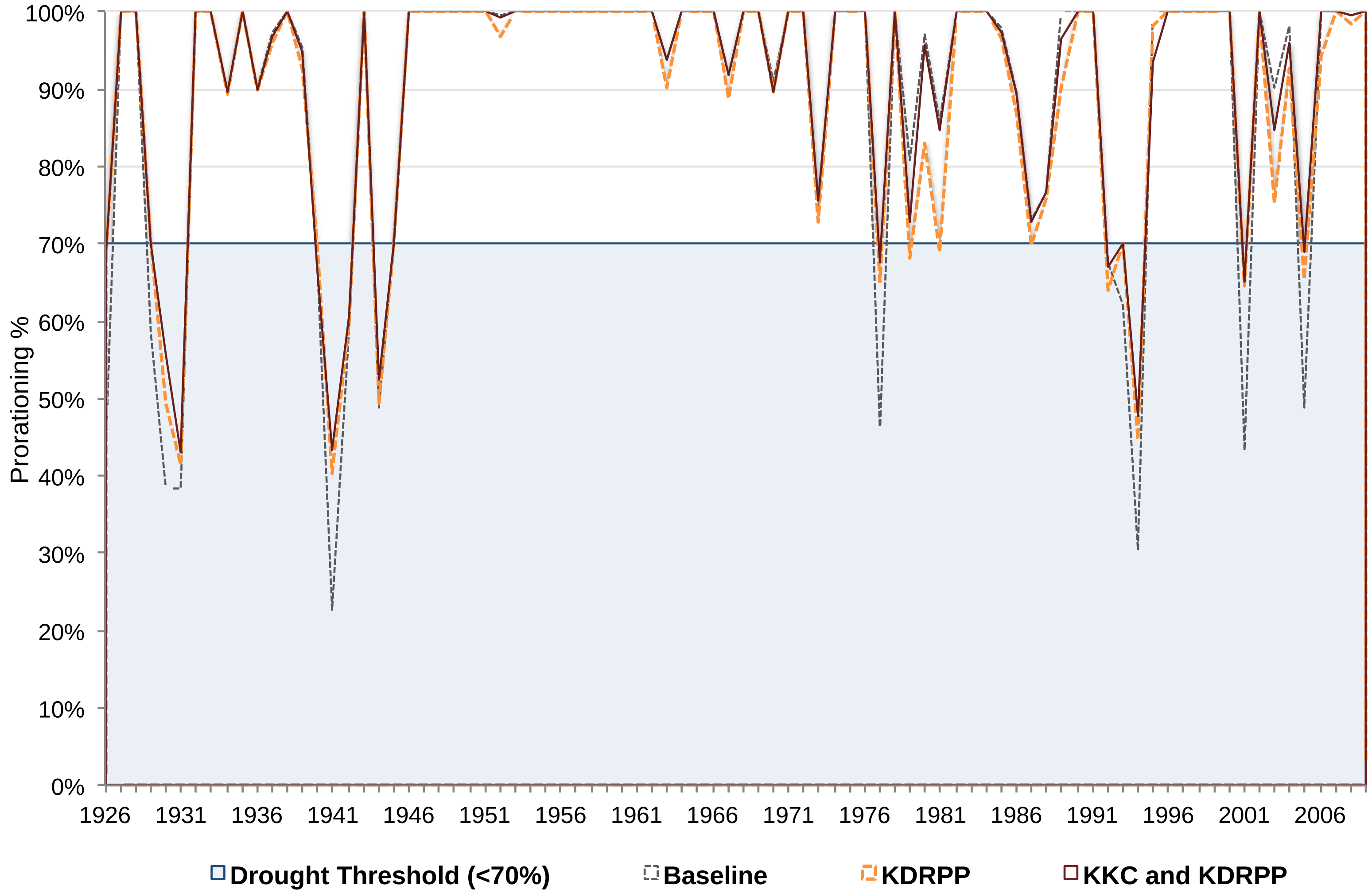
Source: Adapted from Washington State Department of Agriculture, 2013. Note that a pixel showing one square mile of agricultural land is triggered by agricultural activity anywhere within that pixel.

Figure 3. Agricultural Land in the Yakima River Basin

Modeling the KDRPP Water Supply Effects

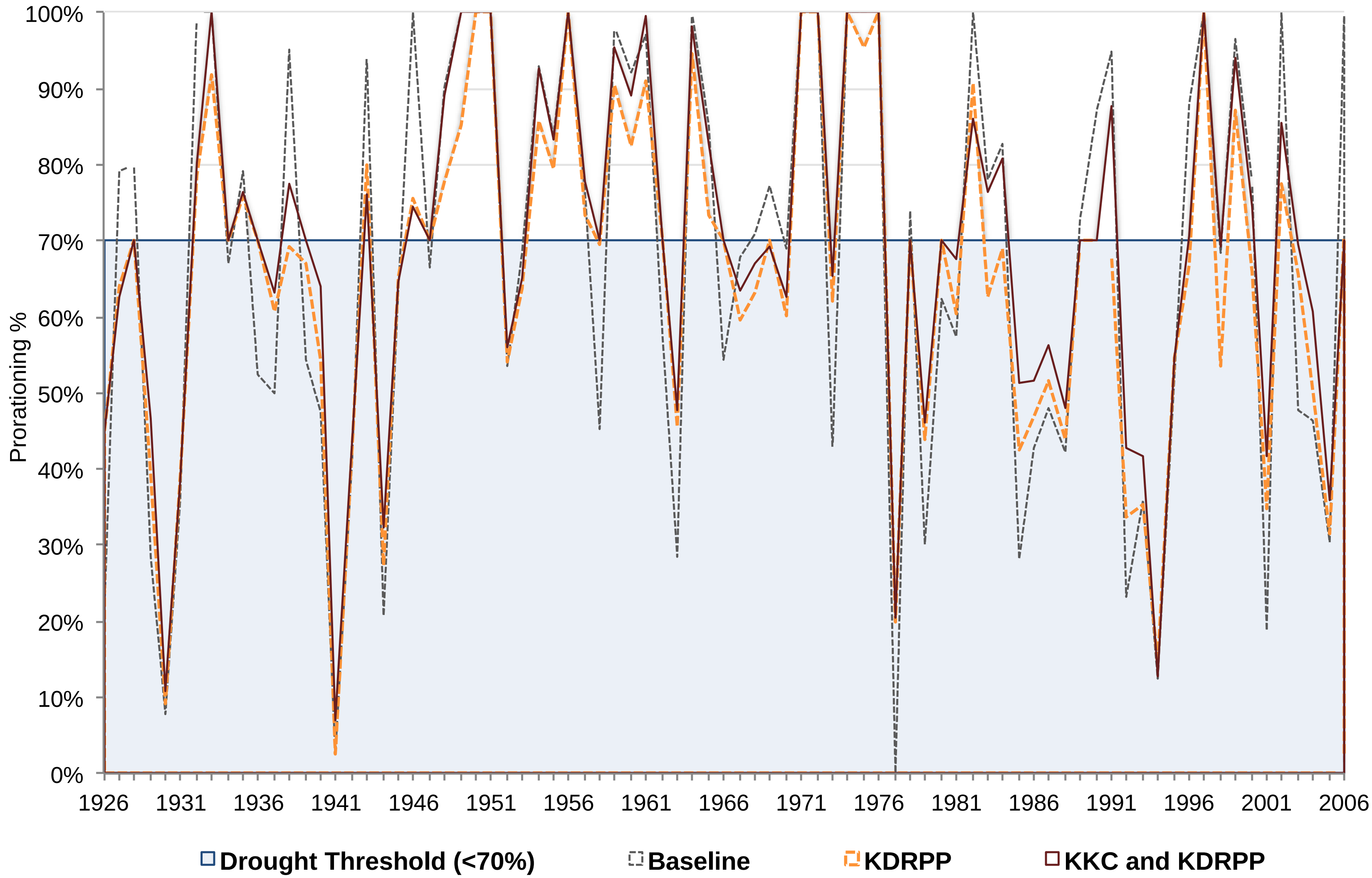
HDR utilized historical water availability data from 1926 to 2009 combined with the YakRW model to estimate the level of prorationing that would have occurred over that period under different scenarios, including the KDRPP, available to water managers (Reclamation and Ecology 2014a). Drought conditions occur throughout the timeframe, and lower prorationing levels correspond to more severe droughts in terms of the amount of water available. The KDRPP (and, in particular, the KDRPP in combination with the KKC) would generally increase water availability compared with the baseline (Figure 4). Under adverse climate change assumptions regarding drought severity and frequency, the pattern remains (Figure 5).

The hydrologic modeling work used as the basis for the NED and RED evaluations focused on effects in years when prorationing would fall below 70 percent without the Integrated Plan. For this reason, results from years above 70 percent are not included in the NED and RED analyses, and rather assumed to supply sufficient water under all alternatives. Therefore, the economic analysis team did not estimate marginal benefits of the KKC or the KDRPP, or both, for years when the baseline conditions involve prorationing of 70 percent or greater.



Source: Adapted from Reclamation and Ecology, 2014a. Note that "prorationing" refers to the share of nondrought allocation available to proratable users. For example, at 50 percent prorationing, all proratable users receive 50 percent of their nondrought allocation.

Figure 4. Predicted Water Availability Associated with the Project Alternatives, Historical Conditions, 1926 – 2009



Source: ECONorthwest with data from Reclamation and Ecology, 2014a. Note that "prorationing" refers to the share of nondrought allocation available to proratable users. For example, at 50 percent prorationing, all proratable users receive 50 percent of their nondrought allocation.

Figure 5. Predicted Water Availability Associated with the Project Alternatives, and Adverse Climate Change Conditions, 1926 – 2006

Because of the considerable variation in net farm earnings by crop (Table 12) combined with the baseline level of market reallocation from lower value crops to higher value crops under drought conditions, additional water is more valuable during more severe droughts than during less severe droughts. The improvement in net farm earnings from increased water availability (reduced prorationing) grows with more high value crop acreage available to use the water that would not have been in production but for the increased water availability. Therefore, it is important to capture the range of drought conditions and their frequencies to understand the value of increased water availability over time.

By sorting the drought years from most severe to least severe, ECONorthwest developed groups of drought years based on drought severity, and used the average value for each group to represent those years. Sorting the years by most severe to the least severe drought conditions shows the differences among alternatives more clearly (Figure 6 and Figure 7). This analysis focuses on the marginal difference provided by a project alternative as measured from the baseline, so baseline years define group years. In this way, one could observe how on average the group of years would have differed with the addition of the KDRPP. Dividing all drought years into groups, and then using the average of the group to represent the group drought severity, allows greater inclusion of the variety and extremes of droughts. In addition, droughts of differing severity have different economic effects per unit of improvement, and grouping them in this way helps to illuminate those effects. To identify a manageable number of groups for both the historical and adverse climate conditions, ECONorthwest used intervals of 3 years under historical conditions, and 7 years under adverse climate change conditions. Timeframes of historical data vary as 84 years of historical drought data exist but adverse climate change drought estimates are only available for 81 years.

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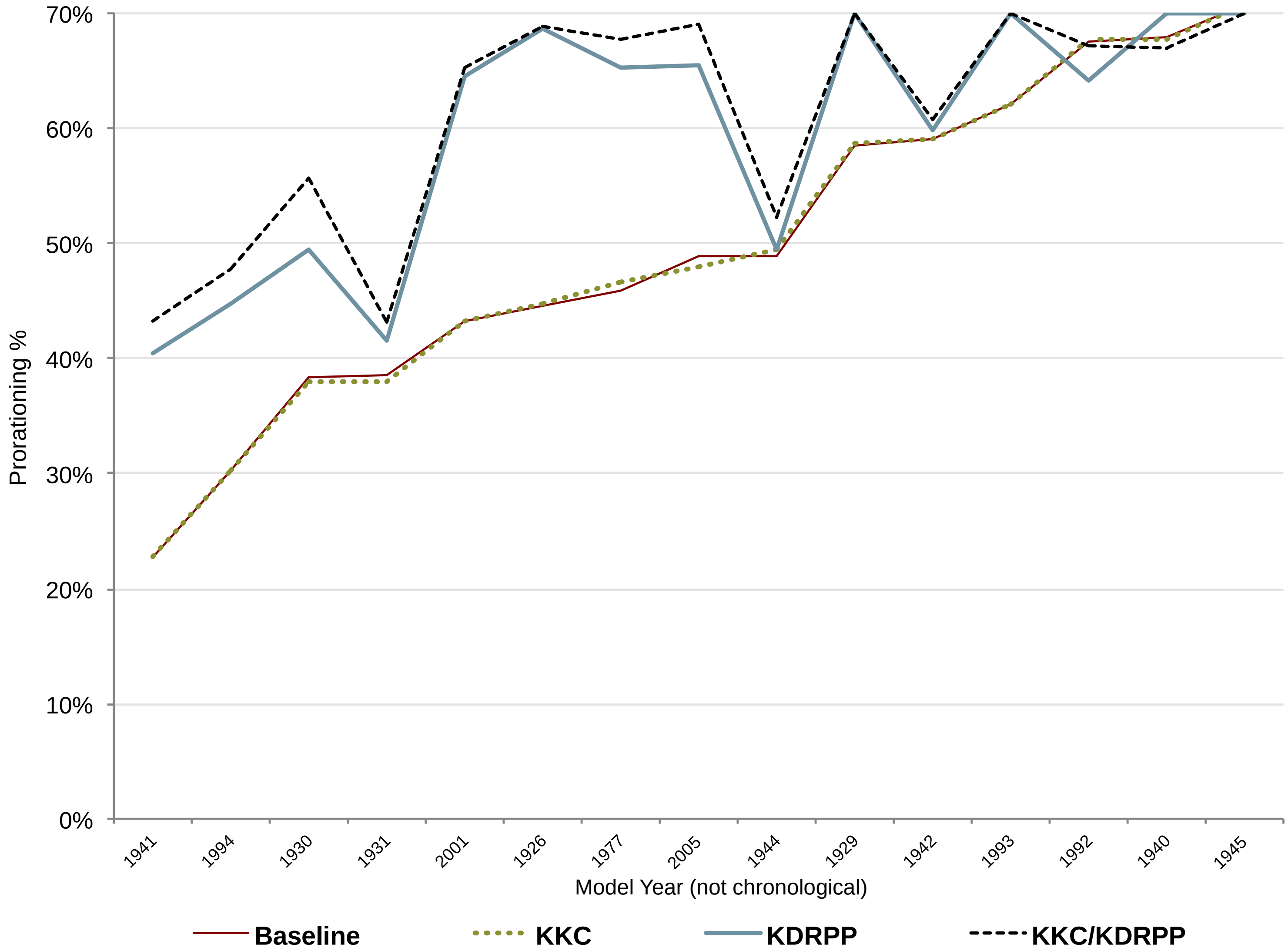
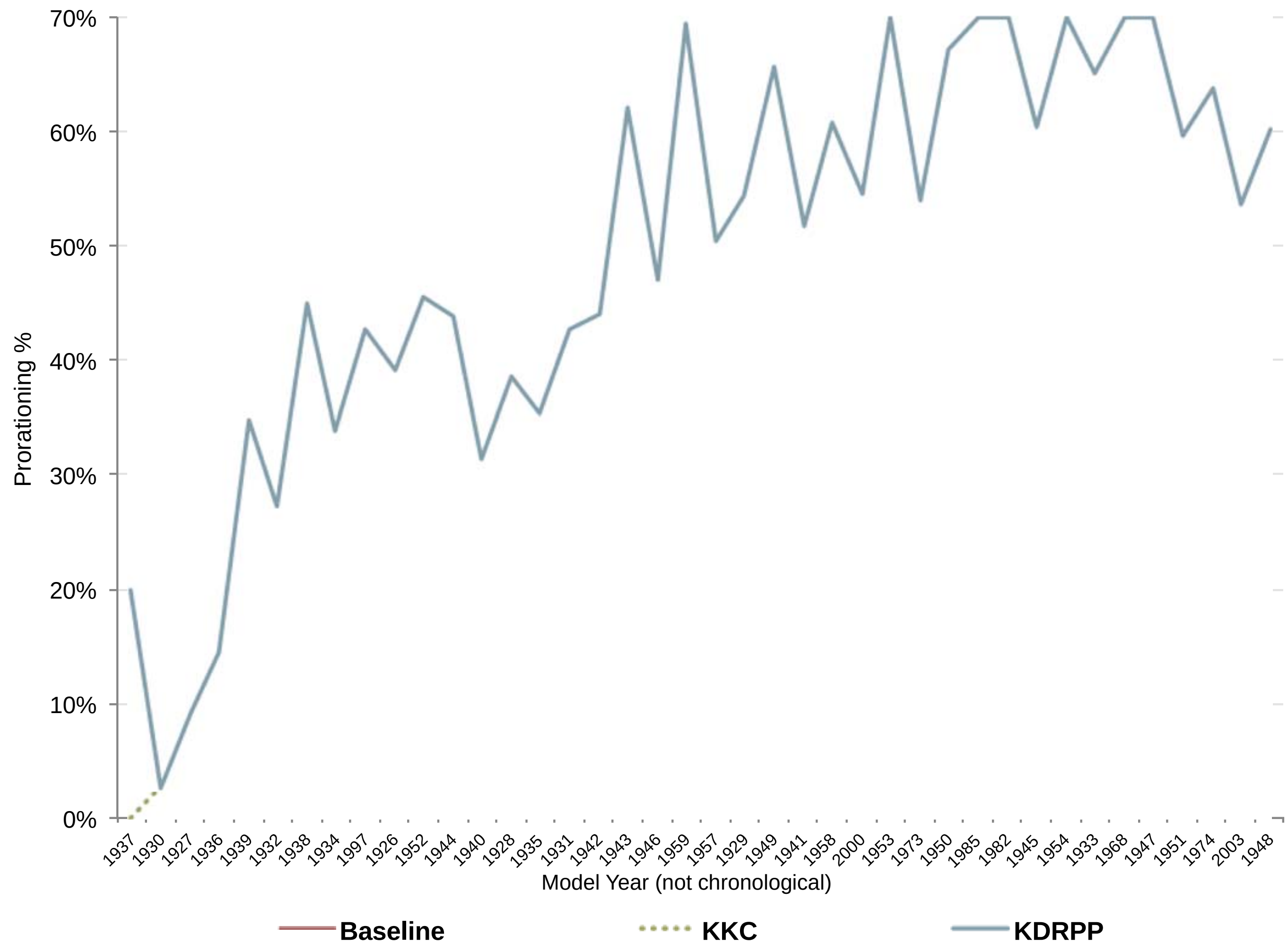


Note: Shows only years with 70 percent or less water availability. Years sorted by baseline drought conditions. Source: Adapted from Reclamation and Ecology, 2014a.

Figure 6. Annual Prorationing Sorted by Drought Intensity, by Alternative, Historical Conditions



Note: Shows only years with 70 percent or less water availability. Years sorted by baseline drought conditions. Source: Adapted from Reclamation and Ecology, 2014a.

Figure 7. Annual Prorationing Sorted by Drought Intensity, by Alternative, Adverse Climate Change

Table 13. Sorted Groups of Water Availability by Scenario, Historical Conditions

GROUP RANGE - 3 YEARS	Baseline Prorationing Percentage	Prorationing Percentage with KKC	Prorationing Percentage with KDRPP	Prorationing Percentage with KKC AND KDRPP
Group 1 – 1941, 1994, 1930	30	30	42	45
Group 2 – 1931, 2001, 1926	42	42	61	63
Group 3 – 1977, 2005, 1944	48	48	60	63
Group 4 – 1929, 1942, 1993	60	60	67	67
Group 5 – 1992, 1940, 1945	69	69	68	68

Note: Table values represent the average value for each group range. Years for range defined by ordering of baseline years from most to least severe droughts in historical record from 1926-2009, and using fixed interval lengths of 3 years. See Reclamation and Ecology, 2014a for drought simulation data and methodology.

The objective of this analysis is to develop an annual expected value (probability-weighted) of each alternative with respect to the baseline. While historical data demonstrate that droughts occur roughly once every five years, their actual occurrence is random and unpredictable. It is, therefore, appropriate to estimate the annual probability of drought. For historical drought conditions, ECONorthwest identified five groups of three years each (Table 13). For adverse climate change conditions and the greater number of drought years, ECONorthwest identified six groups of seven years each (Table 14).

Table 14. Sorted Groups of Water Availability by Scenario, Adverse Climate Change

GROUP RANGE - 7 YEARS	Baseline Prorationing Percentage	Prorationing Percentage with KKC	Prorationing Percentage with KDRPP	Prorationing Percentage with KKC AND KDRPP
Group 1	12	12	22	24
Group 2	29	29	39	44
Group 3	42	43	50	55
Group 4	50	51	59	62
Group 5	59	60	67	69
Group 6	69	70	63	67

Note: Years not shown for each group due to space constraints, but listed on figure axis. Table values represent the average value for each group. Years for range defined by ordering of baseline years from most to least severe droughts as simulated extrapolating from 1926-2006 record, and using fixed interval lengths of 7 years. See Reclamation and Ecology, 2014a for drought simulation data and methodology.

These groups demonstrate the increased water reliability with the KDRPP relative to baseline or the KKC-only alternatives (Figure 8 and Figure 9). Only the most severe drought group averaged below 50 percent prorationing for either alternative involving the KDRPP. Similar patterns hold under adverse climate change conditions, although all alternatives experience more drought years, and more severe droughts (Figure 10 and Figure 11).

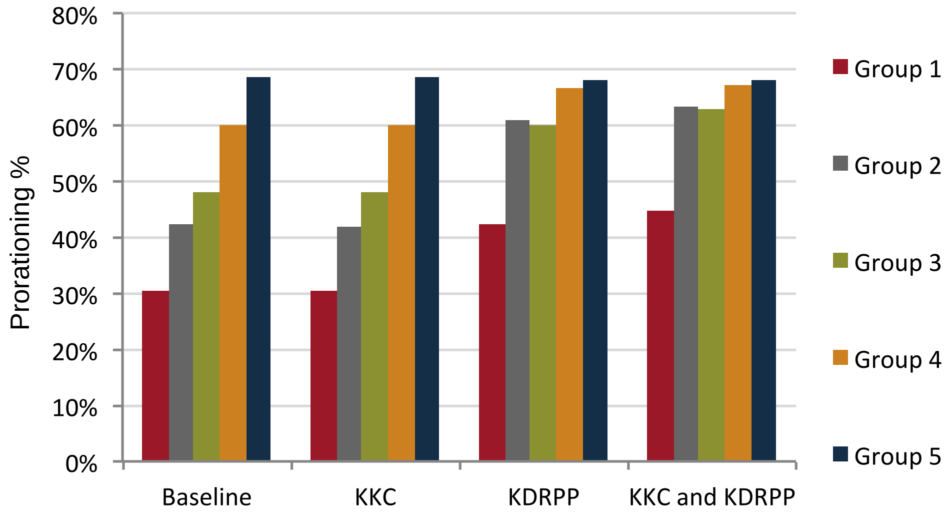


Figure 8. Sorted Intervals of Water Availability by Scenario, Historical Conditions

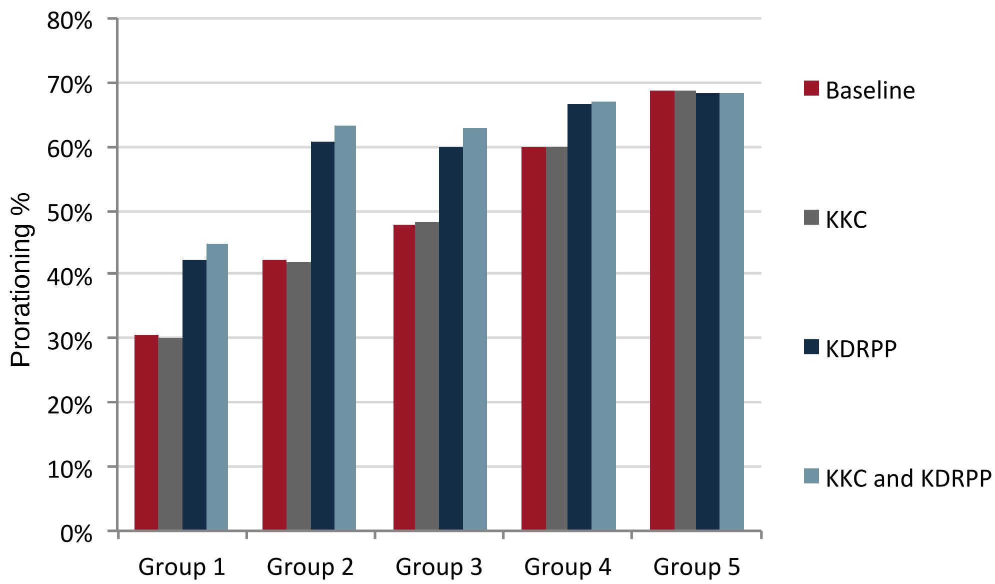


Figure 9. Drought Year Intervals by Alternative, Historical Conditions

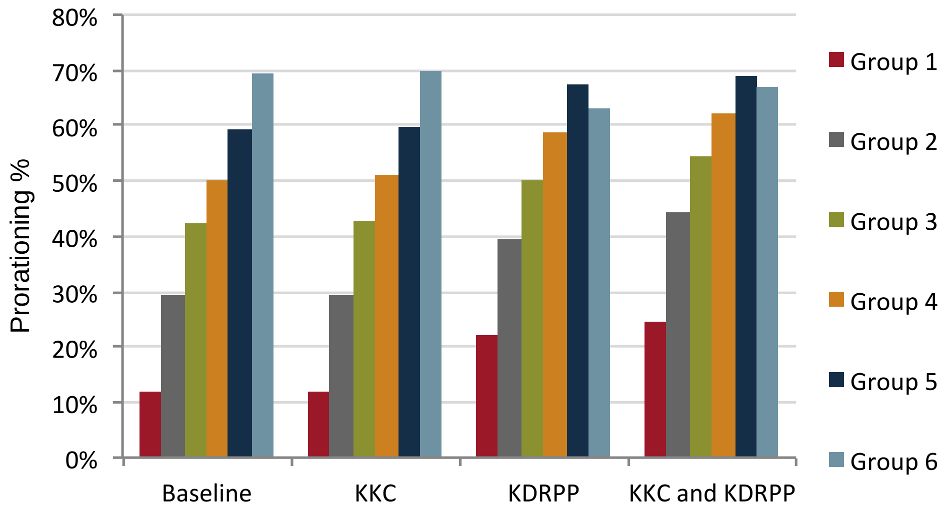


Figure 10. Sorted Intervals of Water Availability by Scenario, Adverse Climate Change

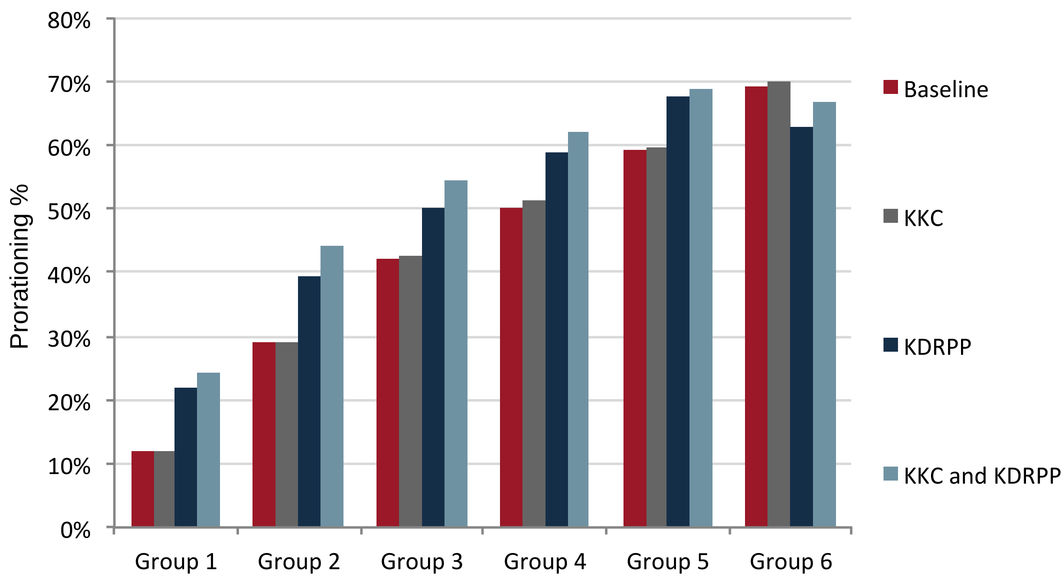


Figure 11. Drought Year Intervals by Alternative, Adverse Climate Change

ECONorthwest calculated net farm earnings for the average prorationing level of each group (Table 15). Under historical conditions, the alternative of the KDRPP provided substantial drought relief beyond baseline conditions, and the addition of the KKC to the KDRPP alone alternative provided additional benefit (Table 15 and Table 16). When probabilistically weighing intervals across all years under historical climate conditions, the KDRPP provides $7.5 million annually in terms of increased net farm earnings relative to the baseline, and $214 million in net present value summing over the 100-year timeframe and discounted at

3.375 percent. When combined with the KKC, these benefits increase to $8.7 million annually and $248 million over 100 years (Table 17).

Table 15. Annual Net Farm Earnings by Group Water Availability, Historical Conditions

GROUP RANGE - 3 YEARS	BASELINE	KKC	KDRPP	KKC AND KDRPP
Group 1	$451,704,774	$450,997,233	$508,417,302	$520,225,929
Group 2	$507,693,204	$507,290,657	$588,435,675	$597,471,905
Group 3	$535,458,100	$535,896,403	$585,350,084	$596,516,182
Group 4	$584,832,116	$585,186,394	$609,863,778	$610,877,794
Group 5	$616,833,454	$616,850,350	$614,527,351	$614,548,186

Note: Values represent model estimates for net farm earnings based on average prorationing level for each group.

Table 16. Annual Net Farm Earnings by Group Water Availability Net of Baseline, Historical Conditions

GROUP RANGE - 3 YEARS	BASELINE	KKC	KDRPP	KKC AND KDRPP
Group 1	-	-$707,540	$56,712,529	$68,521,156
Group 2	-	-$402,547	$80,742,471	$89,778,701
Group 3	-	$438,303	$49,891,985	$61,058,082
Group 4	-	$354,278	$25,031,662	$26,045,678
Group 5	-	$16,896	-$2,306,103	-$2,285,268

Note: Values represent differences between baseline and each alternative model estimate for net farm earnings based on average prorationing level for each group.

Table 17 Composite Net Farming Earnings and Net of Baseline, Annually and 100-Year NPV, Historical Conditions

	BASELINE	KKC	KDRPP	KKC AND KDRPP
Group Composite	$96,304,345	$96,293,608	$103,806,935	$104,987,143
Composite versus Baseline	-	-$10,736	$7,502,591	$8,682,798
NPV (Total Earnings)	$2,750,228,752	$2,749,922,155	$2,964,485,347	$2,998,189,333
NPV (Marginal Earnings)	-	-$306,598	$214,256,595	$247,960,580

Note: Values based on weighting by overall sample size of all years (drought and nondrought) from results of preceding tables to provide an annual value for 100 years. Net present value calculations based on 3.375 percent discount rate.

Similar patterns and results exist under adverse climate change conditions, with greater overall benefits in terms of net farm earnings relative to baseline conditions (Table 18 and Table 19). The annual benefits of the KDRPP alone climb to $14.6 million and yield $315 million over the

100-year timeframe in net present value discounted at 3.375 percent. The addition of the KKC increases annual benefits to $21.6 million and discounted 100-year benefits to $414 million (Table 20).

Table 18. Annual Net Farm Earnings by Group Water Availability, Adverse Climate Change

GROUP RANGE - 7 YEARS	BASELINE	KKC	KDRPP	KKC AND KDRPP
Group 1	$362,193,300	$362,221,510	$409,821,367	$421,542,299
Group 2	$445,426,731	$445,780,660	$494,074,387	$517,437,918
Group 3	$508,637,146	$510,008,828	$545,160,207	$563,098,334
Group 4	$545,293,503	$549,271,338	$580,270,726	$592,774,043
Group 5	$582,921,795	$583,939,729	$612,770,045	$617,364,813
Group 6	$618,469,981	$620,475,392	$596,298,033	$610,412,800

Note: Values represent model estimates for net farm earnings based on average prorationing level for each group.

Table 19. Annual Net Farm Earnings by Group Water Availability Net of Baseline, Adverse Climate Change

GROUP RANGE - 7 YEARS	BASELINE	KKC	KDRPP	KKC AND KDRPP
Group 1	-	$28,210	$47,628,067	$59,348,998
Group 2	-	$353,928	$48,647,656	$72,011,186
Group 3	-	$1,371,682	$36,523,061	$54,461,188
Group 4	-	$3,977,835	$34,977,224	$47,480,540
Group 5	-	$1,017,934	$29,848,250	$34,443,018
Group 6	-	$2,005,410	-$22,171,948	-$8,057,182

Note: Values represent differences between baseline and each alternative model estimate for net farm earnings based on average prorationing level for each group.

Table 20. Composite Net Farming Earnings and Net of Baseline, Annually and 100-Year NPV, Adverse Climate Change

	BASELINE	KKC	KDRPP	KKC AND KDRPP
Group Composite	$255,245,205	$255,974,788	$269,866,231	$276,885,850
Composite vs Baseline	-	$729,583	$14,621,026	$21,640,646
NPV (Total Earnings)	$5,004,515,013	$5,014,708,496	$5,319,733,627	$5,436,259,031
NPV (Marginal Earnings)		$10,193,482	$315,218,614	$431,744,018

Note: Values based on weighting by overall sample size of all years (drought and nondrought) from results of preceding tables to provide an annual value for all 100 years. Net present value calculations based on 3.375 percent discount rate.

Overall, the benefits of the KDRPP for agriculture through reduced prorationing during droughts can reach into several millions annually on average weighted across the full 100-year timeframe, when accounting for the frequency and severity of drought, under both historical conditions and adverse climate change projections. Benefits increase with the addition of the KKC, and the marginal gains over the KDRPP alone are greater than the sum of the KKC alone and the KDRPP alone. In total, under these estimates, the KDRPP could generate $200 to 300 million or more in discounted net present value for agriculture reliability, and this increases to over $400 million with the addition of the KKC.

There is considerable uncertainty regarding likely future drought severity and frequency patterns for the Yakima River basin. Choosing varying lengths of historical data generate quite varied average annual estimates. When combined with adverse climate conditions, these estimates can vary even more widely. Without assuming historical conditions for the first 20 years of the timeframe, and rather assuming adverse climate change conditions for the entire 100 year timeframe, the benefit of the KDRPP over 100 years climbs to $417 million, and the total benefit of the KKC combined with the KDRPP climbs from $432 million to $618 million (Table 21).

Table 21. Net Farm Earnings Benefits of the KDRPP

	KDRPP ALONE	KDRPP WITH KKC
Annual, with Historical Conditions	$7.5 million	$8.7 million
100-Year NPV, with Historical Conditions	$214 million	$248 million
Annual, with Climate Change	$15 million	$22 million
100-Year NPV, with Climate Change	$315 million	$432 million

Note: Net present value calculations based on 3.375 percent discount rate.

Water Supply for Municipal Use

The City of Yakima has 5,083 acre-feet of proratable entitlements, as well as other water rights (Reclamation and Ecology, 2011). The city is moving forward with plans for aquifer storage and recovery (ASR) by injecting water through its wells into the aquifer during nondrought years, and anticipates meeting all drought needs via this strategy. Currently, the city has two wells capable of ASR, and two additional wells would provide sufficient capacity. The city is still in the process of obtaining State permits to conduct ASR, but in 2014 demonstrated ASR technical feasibility.

Yakima's water manager reported that the appropriate tradeoff for valuation of water supply is avoided groundwater pumping during droughts. Yakima reports that the operation of one of its groundwater well pumps with a capacity of 3,000 gallons per minute costs $20,000 a month. This equates to $50 per acre-foot of water. This cost per acre-foot of water is within the ranges discussed in the technical report describing the ASR program (Golder, 2014).

Considering years experiencing droughts during baseline conditions (historical and adverse climate change conditions), the KDRPP provides a 10.5 percent improvement in water availability during the average drought over the baseline under historical conditions, and a 6.9 percent improvement under adverse climate change conditions. While the average drought-year improvement is greater under historical conditions, drought years are much more frequent under adverse climate change. Pumping costs do not vary with drought severity, so it is not necessary to account for different drought severities, as with agriculture. The average drought year benefit associated with the KDRPP under historical conditions equates to approximately 533 acre-feet and $26,417 in avoided pumping costs, and roughly 352 acre-feet and $17,461 in avoided pumping costs with climate change conditions (Table 22). Accounting for the increased frequency of droughts under adverse climate change conditions, these values equate to an expected average annual value of $4,403 under historical climate conditions and $8,623 under adverse climate conditions. Discounted over 100 years, these are $125,734 and $185,584 in net present value respectively.

Reclamation assumes that the modeled adverse climate change conditions would begin to occur after 20 years. As with irrigation benefits, the net present value for municipal benefits in this section under adverse climate change assume historical conditions for the first 20 years, followed by adverse climate change conditions for the following 80 years.

Table 22. Avoided Municipal Groundwater Pumping Costs, City of Yakima

SCENARIO	PRORATIONING (PERCENTAGE)	ACRE-FEET AVAILABLE	DROUGHT YEAR AVOIDED COST	AVERAGE ANNUAL	NPV
Baseline	48.3	2,456	-	-	-
KDRPP only	58.8	2,989	$26,417	$4,403	$125,734
KKC & KDRPP	60.5	3,077	$30,803	$5,134	$146,612
Baseline CC	42.3	2,150	-	-	-
KDRPP only, CC	49.2	2,503	$17,461	$8,623	$185,584
KKC & KDRPP, CC	52.7	2,677	$26,120.81	$12,899	$256,748

Source: Avoided costs based on Brown, 2014. City of Yakima water rights based upon Reclamation and Ecology, 2011. CC represents adverse climate change assumptions.

The City of Ellensburg also has proratable water rights of 6,000 acre-feet (Reclamation and Ecology, 2011). Ellensburg does not yet have an ASR program. Assuming drought could force Ellensburg to purchase water as described and analyzed in Reclamation and Ecology 2012b, the acquisition costs would be $267 per acre-foot in 2014 dollars. Under these assumptions, the KDRPP, in terms of the value of increased water reliability and reduced water purchase costs, would provide a benefit worth $168,282 during the average drought year under historical conditions and $111,230 during the average drought year under adverse climate change conditions (Table 23). The lower annual value per drought year is a result of the increase in overall number of drought years, which increases the overall benefit under adverse climate change conditions. The greater frequency of drought years under adverse climate change equates to $1.2 million in net present value over 100 years for adverse climate change, while historical conditions would experience $800,958 in net present value over 100 years.

Table 23. Avoided Municipal Water Purchase Costs, City of Ellensburg

SCENARIO	PRORATIONING (PERCENTAGE)	ACRE-FEET AVAILABLE	DROUGHT YEAR AVOIDED COST	AVERAGE ANNUAL	NPV
Baseline	48.3	2,899	-	-	-
KDRPP only	58.8	3,528	$168,282	$28,047	$800,958
KKC and KDRPP	60.5	3,633	$196,226	$32,704	$933,961
Baseline CC	42.3	2,538	-	-	-
KDRPP only, CC	49.2	2,954	$111,230	$54,928	$1,182,219
KKC and KDRPP, CC	52.7	3,160	$166,397	$82,171	$1,635,558

Source: City of Ellensburg water rights based upon Reclamation and Ecology, 2011. Water purchase cost based on Reclamation and Ecology, 2012b. CC represents adverse climate change assumptions.

The sum of these benefits for the two communities represents $0.9 to $1.4 million over the 100-year timeframe for the KDRPP alone (Table 24). If the City of Ellensburg developed an ASR program, these avoided costs in total for the two cities would be less than $500,000 for the 100-year timeframe. If ASR is unsuccessful and the City of Yakima also purchased water, the avoided costs could climb to $2 million over 100 years.

Under the assumption that all 100 years of the timeframe experience adverse climate change conditions, the combined value of the KDRPP for the communities of Yakima and Ellensburg climb to $1.4 million, and $1.9 million for the combined the KKC and the KDRPP scenario.

Table 24. Avoided Municipal Water Costs, Cities of Yakima and Ellensburg Combined

SCENARIO	PRORATIONING (PERCENTAGE)	ACRE-FEET AVAILABLE	DROUGHT YEAR AVOIDED COST	AVERAGE ANNUAL	NPV
Baseline	48.3	5,354	-	-	-
KDRPP only	58.8	6,517	$194,699	$32,450	$926,691
KKC and KDRPP	60.5	6,710	$227,029	$37,838	$1,080,573
Baseline CC	42.3	4,689	-	-	-
KDRPP only, CC	49.2	5,457	$128,691	$63,551	$1,367,802
KKC and KDRPP, CC	52.7	5,838	$192,518	$95,070	$1,892,306

Note: Based on individual tables above. CC represents adverse climate change assumptions.

3.2.2 Unquantified Benefits

The KDRPP has other categories of potential benefits that could arise that are unquantified at this time. The increased flexibility and option value of the KDRPP operations, both for consumptive uses (primarily irrigation) and instream habitat effects, would likely provide situational benefits that are difficult to predict at this time. Water transactions for example, require adaptability so that water can be used even if the geography or timing of demand varies somewhat. This can hold for both out-of-stream and instream uses. It is not possible to predict the full range of potential future water transactions that could be beneficial and might be facilitated by the flexibility in the storage the KDRPP would provide, either alone or in conjunction with the KKC.

The option value might also allow more efficient uses of other components of water supply systems in the Yakima River basin. For example, if additional storage or diversion capacity were available because of the KDRPP, Reclamation might use other storage more freely, such as drawing down another reservoir to lower levels that might otherwise seem too risky without the availability of additional dry-year supply from the KDRPP. This could become more important to the extent that multi-year droughts become more frequent, and managing available storage capacity becomes more challenging.

Bull Trout Enhancement Program

The U.S. Fish and Wildlife Service listed bull trout populations in both Keechelus Reservoir and Kachess Reservoir watersheds as “threatened” under the Endangered Species Act. These two sub-populations are among the numerically lowest populations in the Yakima River basin. The BTE program would generate long-term benefits for bull trout populations in both the Keechelus and Kachess Reservoir watersheds. Reclamation and Ecology would activate the BTE in conjunction with either the KKC or the KDRPP.

Reestablished year-round tributary passage from Keechelus Reservoir into Gold Creek and Cold Creek; and potentially from Kachess Reservoir into the upper Kachess River would increase the number of spawning fish and the redds they deposit. While quantitative projections are not available, Federal biologists indicate this would lead to increased population productivity and abundance. Artificial nutrient enrichment of these watersheds would most directly increase juvenile abundance with the expected improvement in the prey base for sub-adult and adult bull trout residing in the reservoirs. This would also result in expected increase in growth, condition factors, and survival rates, which over time would result in an increase in population abundance and productivity. In addition, artificial nutrient enrichment would be beneficial to the future reintroduction of sockeye into these two reservoirs. If proven feasible, there is the potential to expand the amount of spawning and juvenile rearing habitat in Box Canyon Creek above the lowest impassable falls by approximately 3 miles, which would lead to increased population abundance for the Box Canyon population. Reestablished passage into Cold Creek in the Keechelus Reservoir would open up approximately 2.2 miles of habitat that is currently inaccessible.

The BTE plan also has the potential to accelerate the rate of population recovery greatly in terms of abundance and increased genetic diversity for the Keechelus and Kachess populations by translocation of fish from healthier populations in the Yakima River basin.

Reclamation expects these collective actions to increase bull trout abundance, productivity, and genetic diversity for the Keechelus and Kachess populations. Because of these actions, these populations should become more resilient to the natural fluctuation in environmental factors that can negatively impact population abundance and productivity. These actions would also provide benefits for overall ecosystem health in the reservoirs and their tributaries.

Bull trout are a particularly scarce fish species, and high scarcity creates opportunities for high value improvements. Research on the value of listed threatened and endangered species consistently demonstrates the substantial importance to people of protecting and maintaining these rare species (Loomis and White, 1996). Reclamation has not quantified the value of the BTE program because the small fish populations involved are difficult to model accurately, and because means of establishing monetary equivalents are not readily available.

3.2.3 Quantified Costs

The KDRPP involves two alternative construction options based upon two possible locations for the pumping plant: the East Shore Pumping Plant and South Pumping Plant Alternatives. Both alternatives would take an estimated four years of construction to complete (Reclamation and Ecology, 2015c; Reclamation and Ecology, 2015e). Both alternatives involve annual operation and maintenance expenses, including energy costs. They also involve intermittent additional costs over time, the largest of which involves some capital equipment replacement at 50 years. Together, these costs equate to $561 million undiscounted or $446 million discounted for the East Shore Pumping Plant, and $530 million undiscounted or $437 million discounted for the South Pumping Plant (Table 25 and Table 26). The capital construction costs over the first four years dominate overall costs (Figure 12).

Table 25. Project Costs and Discounted Present Value, KDRPP Alternative 1 (East Shore Pumping Plant)

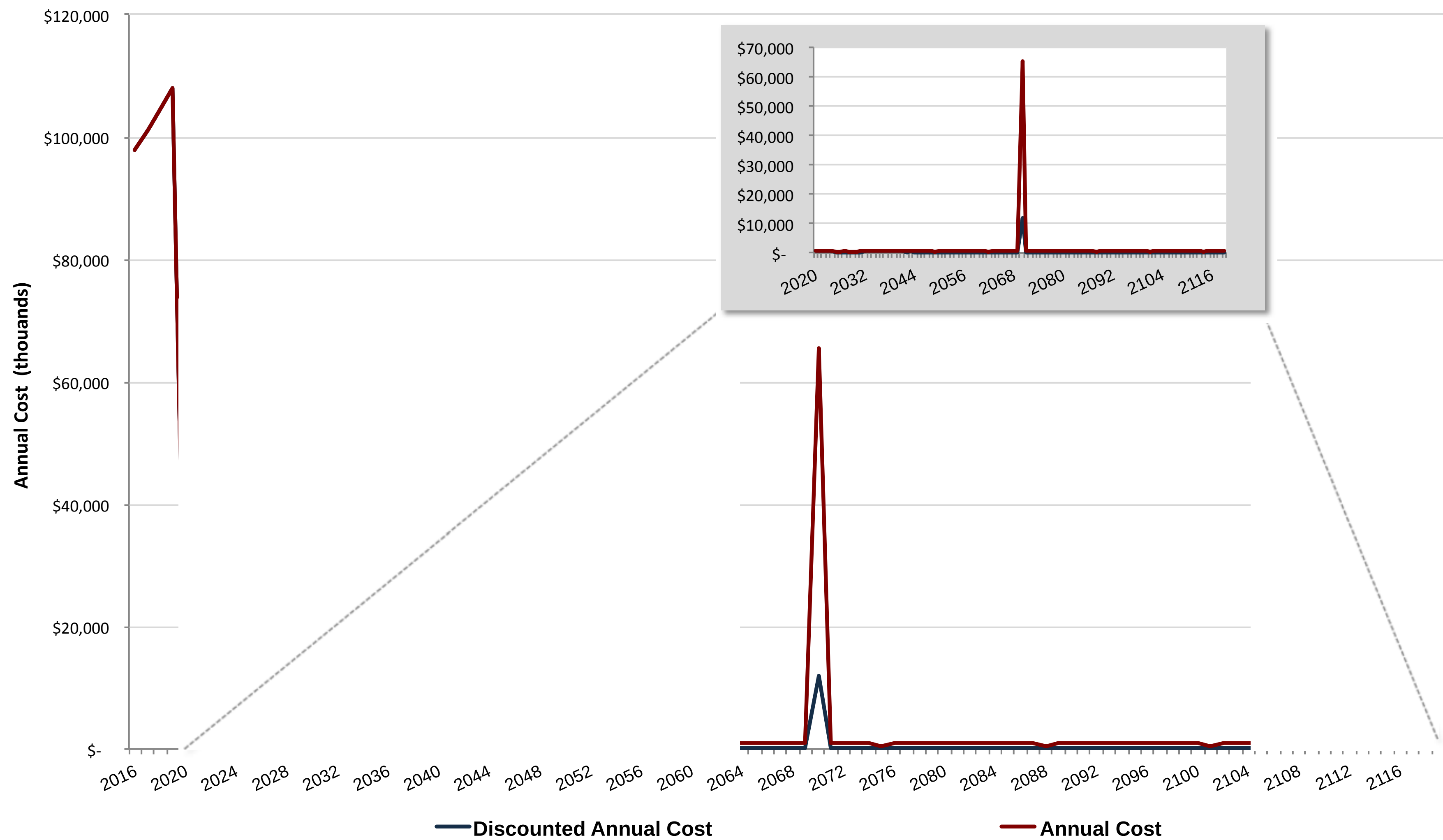
COST CATEGORY	TOTAL	PRESENT VALUE
Field Costs	$318,919,576	N/A
Noncontract Costs	$66,000,000	N/A
Interest During Construction	$26,760,515	N/A
Annual OMR&P	$31,185,985	$8,889,930
O&M	$26,192,500	$7,479,971
Power	$4,993,485	$1,409,959
Nonannual OMR&P	$117,699,730	$25,194,500
O&M	$2,362,500	$641,464
Power	$50,742,480	$12,667,861
Replacement	$64,594,750	$11,885,175
Total	$560,677,638	$445,764,521

Note: OMR&P refers to operation, maintenance, replacement, and power.

Table 26. Project Costs and Discounted Present Value, KDRPP Alternative 2 (South Pumping Plant)

COST CATEGORY	TOTAL	PRESENT VALUE
Field Costs	$317,301,234	N/A
Noncontract Costs	$66,000,000	N/A
Interest During Construction	$26,648,004	N/A
Annual OMR&P	$31,111,172	$8,833,700
O&M	$26,192,500	$7,479,971
Power	$4,918,672	$1,353,729
Nonannual OMR&P	$88,870,165	$18,318,854
O&M	$1,806,000	$445,309
Power	$28,478,415	$7,094,002
Replacement	$58,585,750	$10,779,543
Total	$529,930,574	$437,101,791

Note: OMR&P refers to operation, maintenance, replacement, and power.



Note: Alternative 2, South Pumping Plant, has a similar pattern of costs over time. Source: Adapted from Reclamation and Ecology, 2015e.

Figure 12. Project Costs Over Time, KDRPP Alternative 1 (East Shore Pumping Plant)

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The total discounted and undiscounted annual costs shown above include several distinct components:

- **Field costs** are capital and labor costs from procurement to construction closeout. They include mobilization, materials, fabrication, and installation. These capital costs include contract costs, meaning those directly budgeted items, and construction contingencies based upon percentages. It also includes allowances for unlisted items and procurement strategies.
- **Noncontract costs** are the additional costs Reclamation and Ecology would incur to complete the design, permitting, construction oversight, and administration before and during the construction process.
- Other ongoing costs include **operations, maintenance, replacement, and power** (OMR&P).

The basis of the cost estimates is modeling but not actual bids, so actual costs are likely to differ. For purposes of estimating long-term power costs, Reclamation assumes that pumping at the KDRPP will increase after twenty years due to climate change.

3.2.4 Other Costs

Construction and operation of the KDRPP has the potential to generate other financial and nonfinancial costs. These could include effects such as disruption during construction for access to homes or facilities, and other construction or operational disturbances. Reduced pool levels for Kachess Reservoir, relative to the baseline, could have negative effects for recreation and amenity-based public and private residences adjacent to and near Kachess Reservoir.

Adverse Effects Related to Pool Elevation Changes

By lowering the outlet for the reservoir as part of the KDRPP project, managers would have the ability to tap more water, lowering the reservoir level considerably from current levels during parts of the year, and potentially for periods that extend for several years. The KKC and the KDRPP operating together would allow water from the KKC to contribute to Kachess Reservoir, mitigating pool elevation changes somewhat.

When the KDRPP project is complete and operational, the maximum pool elevation in Kachess Reservoir would remain the same at 2,262 feet. The minimum pool elevation would decrease by about 83 feet. The maximum potential variation from full pool to minimum pool would more than double, from about 67 feet under current conditions to about 150 feet with the KDRPP. Hydrologic modeling of the projects together suggests that over the 85-year period of sample conditions (1924-2009), the pool elevation in Kachess Reservoir would be less than the current minimum pool elevation about 16 percent of the time modeled (Figure 13). The KDRPP project alone would produce minimum pool elevations below the current minimum 20 percent of the time modeled. Under climate change conditions, pool elevations would be below the current minimum 54 percent of the time with the KDRPP alone and 41 percent of the time with the KDRPP and the KKC. Figure 13 shows the minimum pool elevations reached each year for five scenarios: baseline conditions, the KDRPP project alone, the KDRPP and the KKC projects together, and both of those scenarios with climate change. The shaded area indicates the historical minimum pool elevation at about 2,195 feet.

Figure 14 shows the distribution of days where the pool elevation would be below the historical minimum under the project scenarios.

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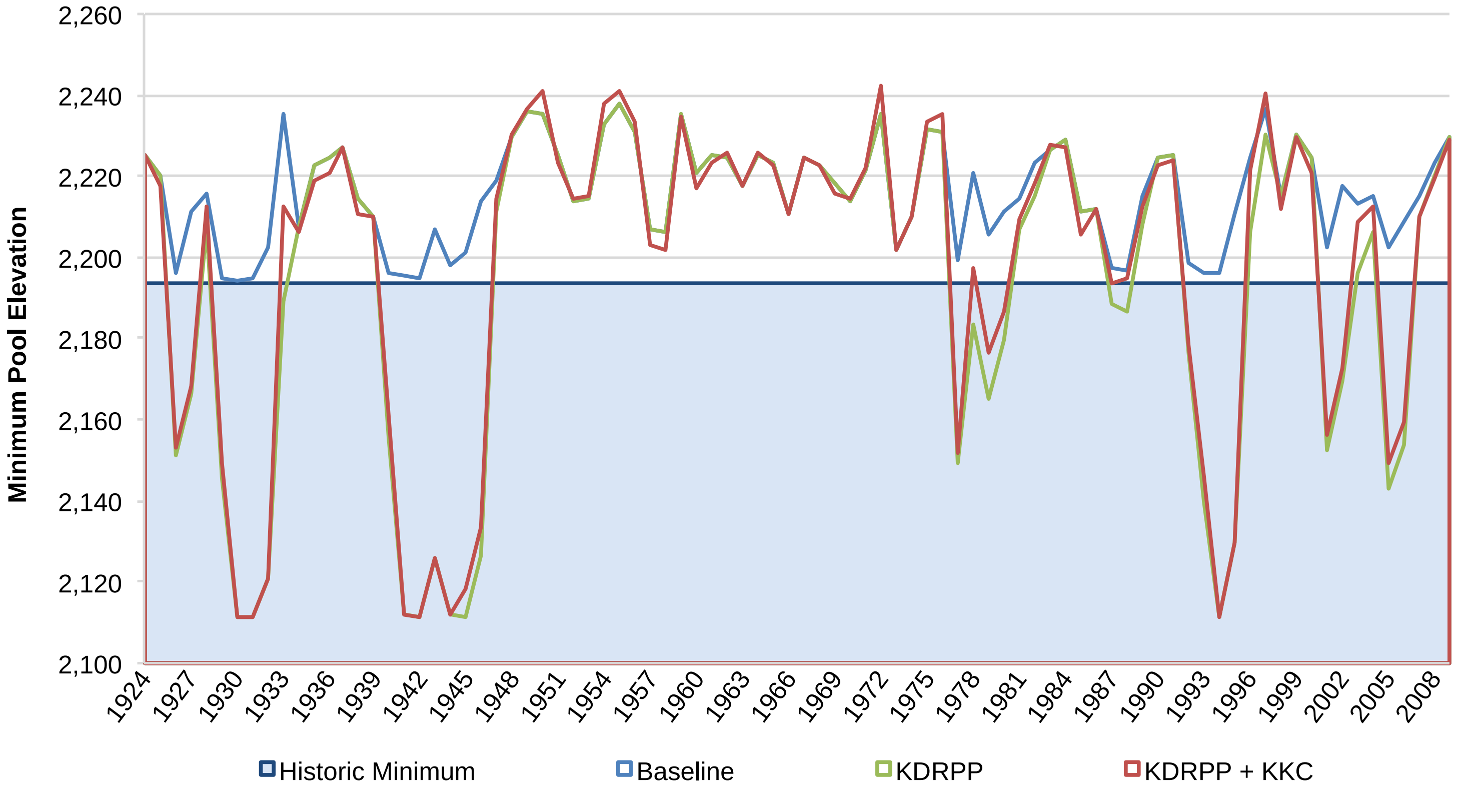
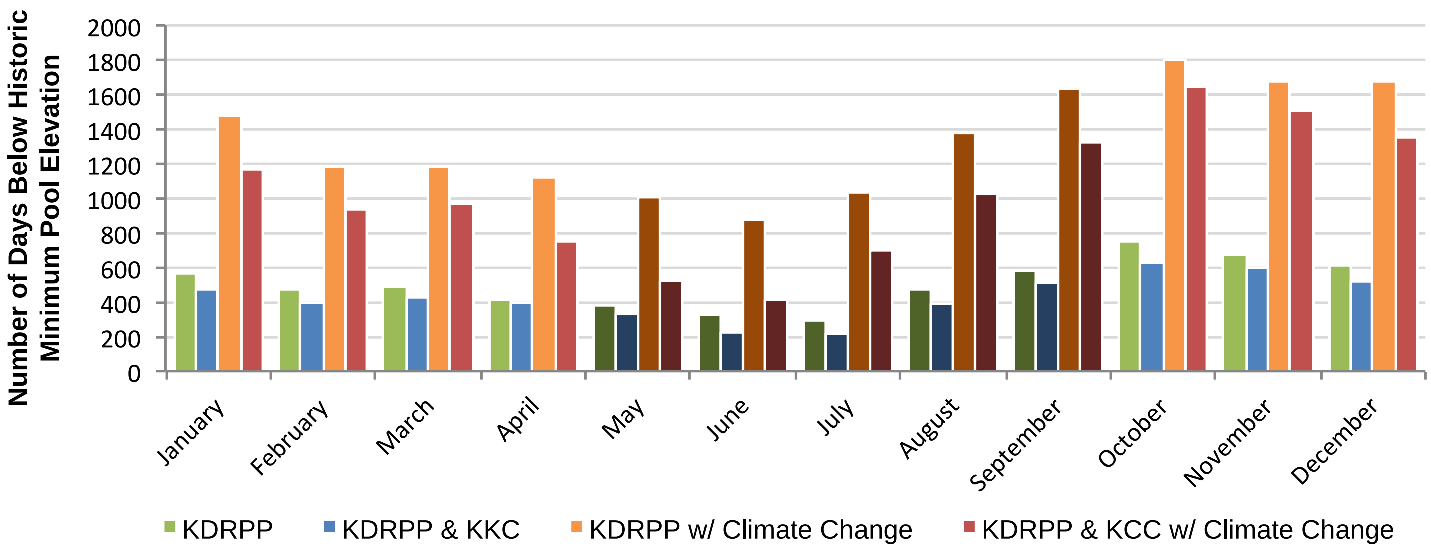


Note: Alternative scenarios represent predicted levels given project options and historical water supply conditions.

Figure 13. Historical and Simulated Kachess Reservoir Pool Elevations, 1924-2008



Note: Alternative scenarios represent predicted levels given project options and historical water supply conditions. Baseline conditions do not allow any elevations below the historical minimum. Darkened columns for May through September represent the primary recreational season.

Figure 14. Number of Days When Pool Elevations are Below the Historical Minimum Under Simulated Scenarios, 1924-2008

This change in the pattern of pool elevations would affect the characteristics of the shoreline and exposure of reservoir bed, and impact the value of resources dependent on current shoreline characteristics and pool elevations. These resources include recreation and aesthetic amenities for private property owners.

Recreational Costs

Recreationists are attracted to the region by the quality of the scenery and in-water and out-of-water recreational opportunities. By reducing the minimum pool elevation, the KDRPP project has the potential to affect the value of in-water and out-of-water recreation adversely in the study area.

Supply of Recreational Opportunities. Kachess Reservoir provides recreational opportunities to day users, overnight visitors, and people who own property surrounding the reservoir. Boating, camping, fishing, hiking, hunting, picnicking, photography, water sports, wildlife watching, and more are available opportunities at Kachess Reservoir. Because Kachess Reservoir is also operated to meet water supply needs downstream, lower water elevations during some parts of the year make recreation, particularly in-water recreation, less desirable than other parts of the year. The reservoir reaches its lowest levels in late summer and is fullest in spring and early summer. Snow and winter weather also limit the types of recreation that people participate in from late fall to spring. Popular winter recreational activities around Kachess Reservoir are cross-country skiing, snowshoeing, sledding, and snowmobiling.

The land surrounding Kachess Reservoir is a mix of public and private ownership (Figure 2). The public land is primarily the Wenatchee National Forest. There are two U.S. Forest Service campgrounds at Kachess Reservoir, one on the west shore and one on the east shore. The east shore offers a group camping site and vault toilet. The west campground is more developed. In addition to campsites, the west campground offers a day-use picnic area and water access at two boat launches. One boat launch is paved and one is gravel, and their operation is dependent on water levels maintained within a certain range.

Outside the campground, the National Forest lands offer dispersed recreational opportunities. These occur along the shoreline during the summer when reservoir levels are lower, as well as in upland areas adjacent to the reservoir. Private lands also offer recreational opportunities for those with legal access to them. They support similar types of opportunities that are available on the National Forest lands.

Opportunities for fishing at Kachess Reservoir are available all year long. The species available for harvest include kokanee, burbot, rainbow trout, and cutthroat trout. The Washington Department of Fish and Wildlife stocks the lake with kokanee and cutthroat trout fry.

Many similar recreational opportunities are available throughout the study area. Keechelus Reservoir, Cle Elum Reservoir, and Lake Easton offer the closest substitute opportunities for recreation if conditions become less desirable or unavailable at Kachess Reservoir. Similar recreational opportunities are available in other reservoirs in the Yakima River basin, including Bumping Lake, Rimrock Lake, and Clear Lake, as well as along the rivers in the study area. Farther afield, similar opportunities are available at Lake Chelan, Lake Wenatchee, and the Columbia River. Access differences, popularity and congestion, and other factors would determine how desirable a substitute each of these locations would be for Kachess Reservoir. Substitutes can include completely different types of recreation as well. During a drought, many of these water bodies may experience similar effects that would adversely affect the quantity and quality of recreation across the Yakima River basin.

Demand for Recreational Opportunities. The measurement of current recreational visitation to the water resources in the Yakima River basin is limited. Comprehensive visitation data do not exist, although visitor counts are available for specific facilities. Table 27 shows the estimated average annual number of visitors to the two campground facilities on Kachess Reservoir. It also shows the use of other recreational areas nearby.

Table 27. Estimated Annual Average Visitation for Recreational Facilities on and Nearby Kachess Reservoir

	OPERATOR	ESTIMATED AVERAGE ANNUAL USE (NUMBER OF VISITORS)
Kachess Campground	USFS	23,000
Kachess Campground Boat Launch	USFS	11,000
East Kachess Group Site	USFS	Not Available
Keechelus Lake Boating Site and Picnic Area	USFS	5,000
Lake Easton State Park	Washington State Parks	212,400

Source: Reclamation and Ecology, 2014b.

The Kachess Campground is the most popular in the Forest Service district and is completely booked most weekends during the summer season. It is open from Memorial Day to mid-September. Year-round camping is available at Lake Easton State Park, and several private resort facilities on Lake Easton. These sites tend to be full during summer weekends as well, and 60 to 70 percent full during the week. Public access to Kachess Reservoir is constrained for much of the winter due to snowed-in roads.

In 2006 and 2007, Reclamation initiated a survey of visitors to the reservoirs in the Yakima River basin, including Kachess Reservoir (Reclamation, 2008b). Table 28 shows the recreational activities participated in by visitors to Kachess Reservoir, and the activities that people identified as their primary purpose for visiting the reservoir during that period. Camping was overwhelmingly the activity that drew visitors to Kachess Reservoir. Kayaking and canoeing was second, with just 10 percent of visitors indicating it as their primary activity. While camping, visitors also engaged in other activities. Swimming, sightseeing, and wildlife viewing were the most popular activities, with over half of visitors participating. Kayaking and canoeing, nature study, motor boating, and fishing followed, with a third to a fifth of visitors participating.

Table 28. Participation Rates for Recreational Activities on Kachess Reservoir

	ALL RECREATIONAL ACTIVITIES (PERCENT OF RESPONDENTS PARTICIPATING)	PRIMARY RECREATIONAL ACTIVITY (PERCENT OF RESPONDENTS)
Motor Boating	22	6
Boat Fishing (Guided)	1	0
Boat Fishing (Private)	18	4
Bank Fishing	19	1
Kayaking/Canoeing	32	10
Hunting	0	0
Sailing	3	0
Water-Skiing	13	4
Jet Skiing	3	0
Swimming	70	6
Camping	93	73
Sightseeing	70	4
Wildlife Viewing	60	1
Nature Study	25	0
Other	23	1

Source: Adapted from Reclamation, 2008b.

While at Kachess Reservoir, about 40 percent of visitors used boat ramps. Almost 80 percent used the beaches. Just 5 percent used floating docks and boat camps on the water. Although the Washington Department of Fish and Wildlife allows fishing and stocks several species, fishing is not a primary activity according to the survey of visitors. Around 20 percent of visitors reported they fished from a boat or from the bank, or both, but just 5 percent of visitors said either bank or boat fishing was the primary reason they visited the reservoir. Very little to no guided fishing takes place on the reservoir.

On average, visitors took between 2 and 6 trips per year to Kachess Reservoir. Boaters took the most trips. Boater trips were generally between 2 and 4 days in length. Visitors took the majority of their trips to Kachess Reservoir during the summer, with around 10 percent of trips each in the spring and fall.

Value of Recreation. The most commonly used measure of value associated with outdoor recreation activity is net economic benefit, also known as consumer surplus, which represents the net benefit after deducting market-based costs associated with the activity (equipment, transportation, etc.)[1]. The U.S. Forest Service provides regional estimates by recreation type for the net value (consumer surplus). Table 29 shows these regional estimates for the recreational opportunities available at Kachess Reservoir.

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[1] Consumer surplus is the measure of value commonly used for recreational activity, because while equipment and travel expenses are determined in markets, recreation sites and access are not typically priced according to market forces.

Table 29. Net Economic Benefit (Consumer Surplus) Values for Recreational Activities Popular at Kachess Reservoir, Per Visitor per Day

ACTIVITY	NET ECONOMIC BENEFIT		
	MINIMUM	MEAN	MAXIMUM
Camping	$9	$128	$275
Cross-country skiing	$59	$59	$59
Fishing	$5	$54	$126
Floatboating/rafting/canoeing	$31	$34	$36
General recreation	$2	$39	$153
Hiking	$0	$28	$159
Hunting	$7	$56	$137
Motorboating	$16	$33	$79
Mountain biking	$38	$61	$96
Other recreation	$91	$91	$91
Picnicking	$19	$79	$175
Sightseeing	$6	$25	$75
Swimming	$7	$33	$73
Wildlife viewing	$8	$89	$426
Horseback Riding	$22	$22	$22
Snowmobiling	$13	$45	$152

Source: Adapted from Reclamation, 2008b and Loomis 2005, updated to 2014 values using the BLS CPI (http://data.bls.gov/cgi-bin/cpicalc.pl).

Combining the number of users who reported using the campground, the primary activities they reportedly engaged in, the average number of days in their trip, and the net economic benefit values per user per day, allows a rough estimate of the value of recreation Kachess Reservoir supports. Table 30 shows these results. The net economic value of recreation per year at Kachess Reservoir is between about $1 million and $18 million.

Water levels currently fluctuate over 60 feet from maximum to minimum pool elevations, with predictable seasonal changes that affect recreation. Many recreational visitors are sensitive to low water levels, and say they lower the quality of their experience. A survey of recreational users to Kachess Reservoir found that the primary factor detracting from an enjoyable experience was low water levels. About 31 percent of those surveyed reported this factor, identifying that low water levels made it difficult to get boats in the water, made fishing poor, and made the lake less scenic (Reclamation, 2008b).

Table 30. Annual Net Economic Benefit of Primary Recreational Activities at Kachess Reservoir

ACTIVITY	TOTAL USER DAYS PER PRIMARY ACTIVITY PER YEAR	NET ECONOMIC BENEFIT		
		MINIMUM	MEAN	MAXIMUM
Motor Boating	3,335	$51,859	$110,633	$262,754
Boat Fishing (Guided)	-	$0	$0	$0
Boat Fishing (Private)	2,001	$10,372	$107,867	$253,073
Bank Fishing	-	$0	$0	$0
Kayaking/Canoeing	6,831	$212,444	$233,689	$247,851
Hunting	-	$0	$0	$0
Sailing	-	$0	$0	$0
Water-Skiing	1,932	$30,043	$64,091	$152,216
Jet Skiing	-	$0	$0	$0
Swimming	4,025	$29,208	$133,523	$292,081
Camping	59,616	$556,217	$7,601,636	$16,377,509
Sightseeing	2,415	$15,021	$60,085	$180,256
Wildlife Viewing	-	$0	$0	$0
Nature Study	-	$0	$0	$0
Other	-	$0	$0	$0
Total	80,155	$905,164	$8,311,524	$17,765,739

Source: Loomis 2005, updated to 2014 values using the BLS CPI (http://data.bls.gov/cgi-bin/cpicalc.pl).

Table 31 shows the total net present value of the recreational activities over a 100-year period of analysis, assuming current conditions, discounted at 3.375 percent. This does not include projection of increased visitation due to population growth or changing preferences over time.

Table 31. Total Present Value of the Net Economic Benefit of Recreational Activities at Kachess Reservoir over 100 Years, Baseline

	TOTAL PRESENT VALUE OF THE NET ECONOMIC BENEFIT		
	MINIMUM	MEAN	MAXIMUM
Total	$25,849,398	$237,357,843	$507,348,313

Source: ECONorthwest, with data from Reclamation, 2008b; Reclamation, 2012; and Loomis, 2005, updated to 2014 values.

Impact on the Value of Recreation. The KDRPP project would decrease the minimum pool elevation, reducing economic value by reducing both the quantity and quality of recreational opportunities in some years. Pool elevation changes would directly affect the amount of boating, swimming, and fishing that happens over time by cutting off access to the water via the boat ramps in some years. It would indirectly affect the quality of activities surrounding the lake, such as camping, sightseeing, and hiking.

As Figure 14 shows with the KDRPP, during drawdown years, pool levels would be below the historical minimum. This would occur throughout the year, including during the summer recreational season from May through September, although these months would experience fewer low pool days proportionally than other months. It is during this season that most of the value shown in

Table 30 accrues to recreational visitors. With the KDRPP project alone, pool elevations would be less than the current minimum during the summer season about 16 percent of the time. With the KDRPP and KKC, pool elevations would be less than the current minimum about 13 percent of the time. Under climate change, this would increase to 47 percent and 32 percent of the time, respectively. However, based on historical conditions, these new low pool levels would not be experienced for decades at a time. In general, entire seasons would experience new, drawn-down levels, with long durations of levels within the current range of pool levels.

Assuming that recreational activity ceases at Kachess Reservoir during these low pool periods, the days of recreation would diminish by the percent of time pool elevations are below the historical minimum. Corresponding economic value of those days, measured by consumer surplus, would diminish as well. For the KDRPP alone, the loss based on average consumer surplus values would be about $38 million, discounted over 100 years. For the KDRPP and the KKC, the loss based on average value would be about $31 million, discounted over 100 years. Under climate change, these losses would increase to $75 million and $53 million, respectively. Table 32 shows the minimum, mean, and maximum loss for each scenario.

Table 32. Net Present Value of Recreational Opportunities Lost during Periods of Pool Elevation below Historical Minimum

SCENARIO	DAYS BELOW HISTORICAL MINIMUM DURING REC SEASON (PERCENT)	NET BENEFIT LOSS		
		MINIMUM	MEAN	MAXIMUM
KDRPP	16	$4,135,904	$37,977,255	$81,175,730
KDRPP (Climate Change)	47	$8,115,717	$74,521,235	$159,287,860
KDRPP & KKC	13	$3,360,422	$30,856,520	$65,955,281
KDRPP & KKC (Climate Change)	32	$5,799,662	$53,254,443	$113,830,457

Source: ECONorthwest, with data from Reclamation 2008b, Reclamation 2012, and Loomis 2005, updated to 2014 values.

The lower to middle range of values shown in Table 32 are probably more appropriate to consider than the upper end of the range, because several factors likely would mitigate the loss in value somewhat:

- Some people may continue to participate in certain activities, such as camping, despite the low pool elevations. They may not derive as much benefit from the activity, but the value would not be zero. Some visitors might find the change due to lower levels interesting if it exposes previously unseen geology and tributary stretches, as with declining reservoir pool levels on the Colorado River.

- Some people may choose to go elsewhere to recreate, either engaging in the same activity or something different. A quarter of respondents to the 2006-2007 survey indicated that Cle Elum Reservoir is the alternate location where they would go to find their desired experience. Almost 40 percent said another reservoir in the Yakima River basin would satisfy their recreational interest (Reclamation, 2008b). Thus, it is likely that many visitors would seek substitute recreational experiences elsewhere in the basin, somewhat offsetting a loss of value associated with the foregone experience at Kachess Reservoir. The Interstate-90 exit for Cle Elum Reservoir is about 20 miles from the exit for Kachess Reservoir. If they travel farther, or if the experience is not a perfect substitute, they may derive less economic benefit from the activity, but the value would not be zero.

If good substitute opportunities exist, or pool level declines do not completely remove certain recreational opportunities, it is unlikely that all visitors lose the full consumer surplus value. Existing studies do not provide examples for observed changes in behavior due to the kinds of effects that the KDRPP would generate, so it is difficult to estimate the precise share of value. The low to middle range for the values provides an approximation.

Diminished Property and Amenity Values

At times when the surface pool level at Kachess Reservoir falls below current operational levels, property owners surrounding the reservoir may experience diminished enjoyment of their property. For those who plan to sell their property, this could translate into monetary losses in terms of lower property values. For those who choose not to sell their property, the effect would occur as nonmonetary losses in use or amenity value.

Table 33 shows the characteristics of parcels where a portion of the parcel is within one-tenth of a mile of Kachess Reservoir. There are almost 200 private parcels comprising almost 1,400 acres with this characteristic (Figure 2). The county assessor reports a total market value for these properties of over $60 million. There are also 36 parcels of public land, which comprise a much larger number of acres because the overall parcel sizes are much larger.

Table 33. Public and Private Property within One-Tenth of a Mile of Kachess Reservoir

	NUMBER OF PARCELS	ACRES[1]	TOTAL MARKET VALUE
Private	197	1,394	$63.2 Million
Public	36,412 36 2,726	9,578	8% N/A

Source: ECONorthwest, with data from Kittitas County Assessor.
[1]Total acres associated with parcels within one-tenth of a mile of the reservoir.

In general, changes in property values for land adjacent to Kachess Reservoir would come about due to changes in recreational opportunities and/or aesthetic amenity values. These kinds of changes would affect a subset of the properties listed in Table 33. Isolating those properties that are private and not categorized for timber or farming purposes, identifies 85 parcels comprising 63 acres. The total assessed value of land and improvements on these parcels is $35.5 million (Table 34). The map in Figure 15 displays these parcels.

Table 34. Private Residential and Recreational Properties Adjacent to Kachess Reservoir

Number of Properties	Total Area (Acres)	Land Market Value	Improvement Market Value	Total Market Value
85	62.6	$21.5 million	$14.0 million	$35.5 million

Source: ECONorthwest, with data from Kittitas County Assessor.

ECONorthwest examined peer-reviewed academic and government literature for examples of the relationship between changes in reservoir levels, shoreline characteristics, and adjacent property values. Six studies were identified and reviewed (Hanson and Hatch 1998; Hatch and Hanson 2001; Lansford and Jones 1995; Loomis and Feldman 2003; Hanson, Hatch, and Clonts 2002; Rodgers, Moore, Saginor, and Brody 2012). The reasons for changes in reservoir levels in these various studies include construction projects, permanent reductions due to changes in water demand, and seasonal variations. These studies generally indicate that a change in reservoir pool level can reduce the value of shoreline properties. The magnitude of this reduction in value depends on the characteristics of the reservoir and surrounding area as well as the specifics of the drawdown timing, frequency, severity, and longevity.

The studies examined exhibited a poor match with the projected effects of the KDRPP on Kachess Reservoir and adjoining properties. Important differences between these studies and the KDRPP include the following:

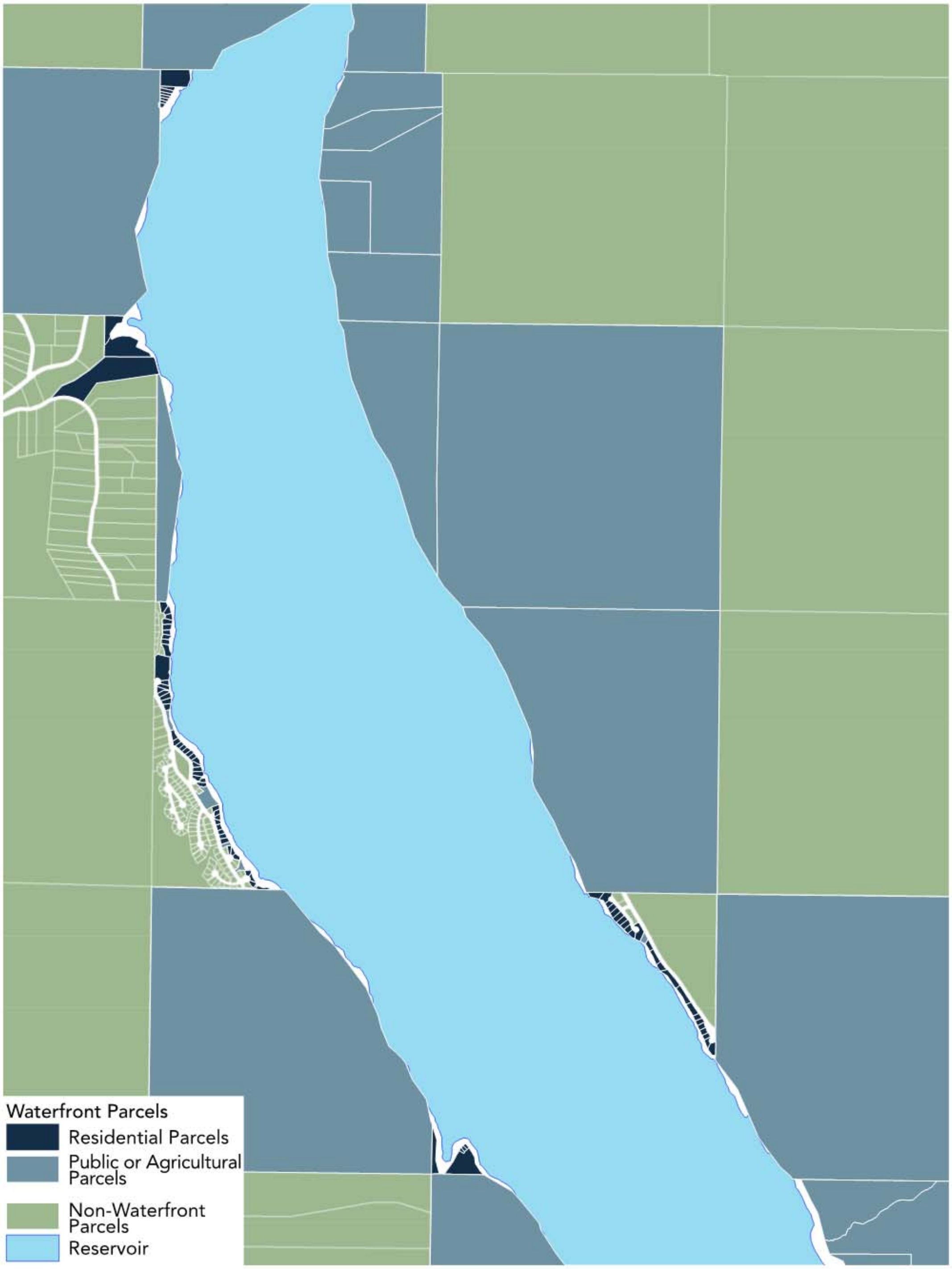
- Reclamation already operates Kachess Reservoir with seasonal drawdowns that affect recreation and visual aesthetic qualities, and has done so since the reservoir was constructed in 1912. The pool level under existing conditions fluctuates by approximately 67 feet, exposing the unvegetated shoreline. Drawdowns at Kachess Reservoir would continue to be intermittent and temporary. In many years there would be no change in pool level compared with current conditions. In some other years, drawdowns would be only slightly deeper than experienced currently. The number of years when the largest increase in drawdown would occur is relatively small (see Figure 13).

  By contrast, many of the drawdowns in the literatures involved one-time, permanent events in places that had not previously experienced seasonal drawdowns.

- None of the studies in the literature included properties surrounding a reservoir similar to Kachess Reservoir. The reservoirs in relevant literature are primarily in the Southeast or Midwestern United States. Many are situated in relatively flat areas, where a relatively shallow drawdown can produce dramatic visual effects.

  By contrast, Kachess Reservoir is situated in a mountain valley. Because of the steeply sloping shoreline in many areas, a comparatively large drawdown has a much smaller effect on the surface area of the reservoir pool.

Because of these considerations, Reclamation and Ecology concluded that the studies reviewed from the literature provide an inadequate basis for a quantitative estimate of the change in property value that would occur with operation of the KDRPP.



Source: ECONorthwest, with data from Kittitas County Assessor.

Figure 15. Private Residential Property Adjacent to Kachess Reservoir

A portion of the potential change in property value would be due to reduced recreational opportunities. Recreational impacts of the KDRPP have been assessed separately as discussed above. Residents and vacation-home owners in the vicinity of Kachess Reservoir enjoy access to a variety of recreational opportunities and aesthetic benefits besides the reservoir itself. Therefore, without a site-specific study, it would be difficult to determine property-value effects separately from the recreation-value effects discussed previously.

Groundwater fluctuations that adversely affect domestic wells may also impact property values. Significant drawdowns that persist over several years may affect about 46 wells drilled in shallow sedimentary aquifers. Although Reclamation plans to mitigate these impacts by drilling wells deeper or supplying substitute water when wells are not able to produce water, uncertainty about well production during droughts could still potentially have an effect on property values.

Based on these considerations, Reclamation and Ecology identify reduction in private property value as a known but unquantified element of the NED account. The magnitude of this reduction will be some fraction of the existing property value for private residential and recreational properties described earlier in this section. More detailed analysis of real estate conditions in the vicinity of Kachess Reservoir would be needed in order to develop a quantitative estimate of this effect.

3.3 RED Analysis

The Regional Economic Development analysis utilizes identified expenditures associated with the KDRPP to identify the value of economic output, the volume of employment, and the amount of income generated by construction and operation of the KDRPP. The categories of expenditures analyzed under the RED analysis include (1) construction of the KDRPP, (2) typical annual ongoing expenditures for operating and maintaining the KDRPP, (3) construction of the Bull Trout Enhancement Plan, and (4) agricultural activity that occurs because of water made available by the KDRPP. These impact estimates do not account for how the U.S. Government or taxpayers would use the money associated with these expenditures if Reclamation and Ecology did not construct the KDRPP. The methodology ECONorthwest used is consistent with the *Principles and Guidelines* cited earlier.

The RED analysis is broken down into the four-county immediate region, the remainder of Washington State, and the State as a whole. To the extent that Reclamation and Washington State would spend these funds within the four-county region without the KDRPP, the net regional impacts would be less. However, it is unlikely that the State and Federal Governments would spend the same dollars in the four-county region without the KDRPP, rather than assigning them to water infrastructure projects elsewhere. The irrigation and agriculture impacts though, do likely represent the net impacts for the region. Without the available water supply, fields would not be in production, produce would not be sold, and revenue would not be generated. The share of final consumer demand for agriculture within the four-county region might be spent similarly without the KDRPP, but the vast majority of these impacts would likely not occur within the region without the water made available by the KDRPP.

Changes in population over time are not incorporated into these analyses, as IMPLAN® data are available for only a snapshot in time, in this case 2012 (the most current available data).

RED results include the following impact measures as defined within IMPLAN®:

- Output: the sum of expenditures, employee income, proprietor income, profits, and taxes

- Personal Income: total payroll cost of the employees paid by the employer. This includes wages/salary, benefits (e.g., health insurance, retirement), and payroll taxes (e.g., social security, unemployment taxes)
- Job Years: full-time equivalent jobs over a full calendar year

3.3.1 Expenditure Categories

KDRPP Construction, Operation, and Maintenance Expenditures

Expenditure categories of construction costs align with IMPLAN® inputs. These expenditures correspond to identifiable costs for the construction period, under both the East Shore and South Pumping Plant Alternatives (Table 35 and Table 36). Reclamation also identifies the average annual ongoing expenditures for analysis in IMPLAN® of a single representative year upon construction completion (Table 37 and Table 38).

Table 35. KDRPP Alternative 1 (East Shore Pumping Plant) Construction Expenditures

EXPENDITURE CATEGORY	TOTAL EXPENDITURES (MILLIONS)
Labor	$126.26
Contractor Overhead & Capital Costs	$192.66
Noncontract Costs	$66.00
Total	$384.92

Table 36. KDRPP Alternative 2 (South Pumping Plant) Construction Expenditures

EXPENDITURE CATEGORY	TOTAL EXPENDITURES (MILLIONS)
Labor	$125.62
Contractor Overhead & Capital Costs	$191.69
Noncontract Costs	$66.00
Total	$383.30

Table 37. KDRPP Alternative 1 (East Shore Pumping Plant) Annual Operating Expenditures

EXPENDITURE CATEGORY	TOTAL EXPENDITURES OF AVERAGE YEAR
Labor	$212,400
Materials and Equipment	$1,110,000
Total	$1,322,400

Table 38. KDRPP Alternative 2 (South Pumping Plant) Annual Operating Expenditures

EXPENDITURE CATEGORY	TOTAL EXPENDITURES OF AVERAGE YEAR
Labor	$212,400
Materials and Equipment	$981,000
Total	$1,193,400

The total construction impacts for the four-county region, when including indirect and induced expenditures for the construction of the KDRPP would involve 1,774 to 1,781 job-years and $96.6 to $97 million in personal income, depending on the construction alternative (Table 39 and Table 40). For the State as a whole, the value of personal income would be $154 to $155 million with 3,022 to 3,034 job-years.

The impacts reported in Table 34 to Table 37, and Table 39, only capture those that are not paid for by local contributions. In other words, these impacts do not include the local money that is simply transferred from one group to another within the defined region. For purposes of this analysis, Reclamation and Ecology used an assumption that local entities such as farmers, irrigation districts, or city and county governments participating in the Integrated Plan would pay for 25 percent of capital costs and 100 percent of operating, maintenance, replacement, and power expenses. Actual contribution levels have not yet been determined.

Table 39. KDRPP Alternative 1 (East Shore Pumping Plant) Construction Impacts Over the Full Construction Period, $ Millions

REGION / IMPACT MEASURE	DIRECT	INDIRECT	INDUCED	TOTAL	MULTIPLIER
4 County Region					
Output	$196.4	$20.7	$49.4	$266.6	1.36
Personal Income	$76.3	$6.3	$14.4	$97.0	1.27
Job Years	1,192	166	423	1,781	1.49
Rest of Washington					
Output	$89.8	$36.8	$61.5	$188.1	2.09
Personal Income	$28.8	$10.4	$18.4	$57.6	2.00
Job Years	601	202	450	1,253	2.09
Total Washington State					
Output	$286.2	$57.5	$111.0	$454.7	1.59
Personal Income	$105.1	$16.7	$32.8	$154.6	1.47
Job Years	1,793	368	873	3,034	1.69

Table 40. KDRPP Alternative 2 (South Pumping Plant) Construction Impacts Over the Full Construction Period, $ Millions

REGION / IMPACT MEASURE	DIRECT	INDIRECT	INDUCED	TOTAL	MULTIPLIER
4 County Region					
Output	$195.6	$20.7	$49.3	$265.5	1.36
Personal Income	$76.0	$6.3	$14.3	$96.6	1.27
Job Years	1,188	165	421	1,774	1.49
Rest of Washington					
Output	$89.4	$36.6	$61.2	$187.3	2.09
Personal Income	$28.7	$10.3	$18.3	$57.3	2.00
Job Years	598	202	448	1,248	2.09
Total Washington State					
Output	$285.0	$57.3	$110.5	$452.8	1.59
Personal Income	$104.7	$16.6	$32.6	$154.0	1.47
Job Years	1,786	367	869	3,022	1.69

During a typical year of operation, the KDRPP would generate approximately 6 job-years with total personal income of $225 thousand to $281 thousand (Table 41 and Table 42). These job-years would last for the life of the KDRPP.

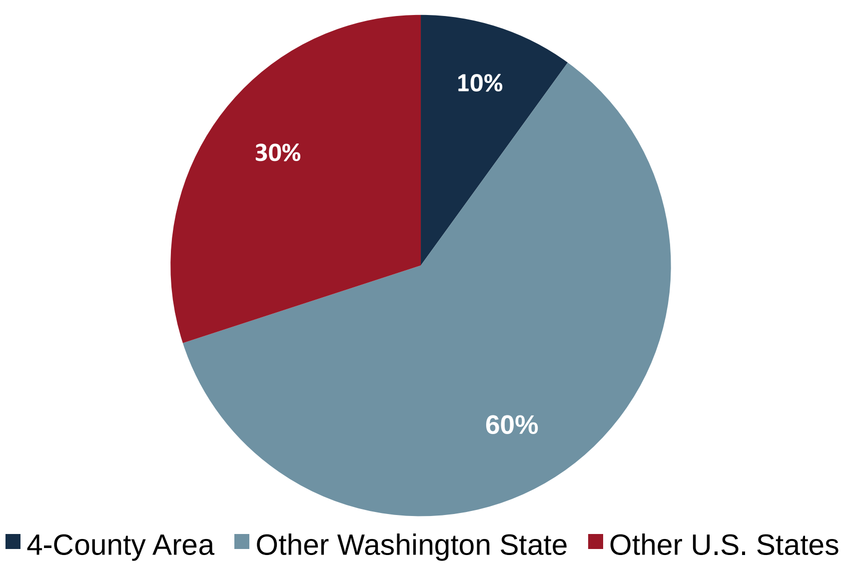
Table 41. KDRPP Alternative 1 (East Shore Pumping Plant) Operating Impacts, Average Annual

REGION / IMPACT MEASURE	DIRECT	INDIRECT	INDUCED	TOTAL	MULTIPLIER
4 County Region					
Output	$484,461	$92,789	$125,818	$703,067	1.45
Personal Income	$158,359	$29,914	$36,628	$224,901	1.42
Job Years	3.2	0.7	1.1	5.0	1.54
Rest of Washington					
Output	$0	$134,148	$48,966	$183,114	-
Personal Income	$0	$42,139	$14,069	$56,208	-
Job Years	0.0	0.8	0.3	1.1	-
Total Washington State					
Output	$484,461	$226,937	$174,784	$886,181	1.83
Personal Income	$158,359	$72,053	$50,697	$281,109	1.78
Job Years	3.2	1.5	1.4	6.1	1.89

Table 42. KDRPP Alternative 2 (South Pumping Plant) Operating Impacts, Average Annual

REGION / IMPACT MEASURE	DIRECT	INDIRECT	INDUCED	TOTAL	MULTIPLIER
4 County Region					
Output	$439,393	$84,157	$114,113	$637,663	1.45
Personal Income	$143,627	$27,131	$33,221	$203,980	1.42
Job Years	2.9	0.6	1.0	4.5	1.54
Rest of Washington					
Output	$0	$121,669	$44,411	$166,080	-
Personal Income	$0	$38,219	$12,760	$50,979	-
Job Years	0.0	0.7	0.3	1.0	-
Total Washington State					
Output	$439,393	$205,826	$158,524	$803,743	1.83
Personal Income	$143,627	$65,350	$45,981	$254,958	1.78
Job Years	2.9	1.3	1.3	5.6	1.89

For purposes of this analysis Reclamation assumed that roughly 10 percent of the capital cost expenditures would accrue in the four-county area, 60 percent would accrue in other Washington State counties, and 30 percent would accrue in other U.S. States (Figure 16). The exact breakdown of these expenditures would depend on the procurement approach, and the contractor(s) Reclamation and Ecology select to perform the work. Reclamation would likely draw 100 percent of operations and maintenance labor from the four-county area.



Source: Reclamation and Ecology, 2014b

Figure 16. Assumed Geographic Distribution of Capital Expenditures

Bull Trout Enhancement Plan Construction Expenditures

The Bull Trout Enhancement Plan would include $13.3 million in expenditures for construction (Table 43). For economic modeling, Reclamation assumed a four-year construction period. These expenditures would generate 59 job-years within the four-county region, and 98 job-years for the State as a whole, with $5 million in personal income for the total (Table 44). If Reclamation also constructs the KKC, then the KKC would share in the BTE impacts.

Table 43. Bull Trout Construction Expenditures

EXPENDITURE CATEGORY	TOTAL EXPENDITURES (MILLIONS)
Labor	$4.65
Contractor Overhead & Capital Costs	$7.10
Noncontract Costs	$1.55
Total	$13.30

Source: Adapted from Reclamation and Ecology, 2014b.

Table 44. Bull Trout Construction Impacts Over the Full Construction Period, $ Millions

REGION / IMPACT MEASURE	DIRECT	INDIRECT	INDUCED	TOTAL	MULTIPLIER
4 County Region					
Output	$6.7	$0.7	$1.6	$9.0	1.34
Personal Income	$2.6	$0.2	$0.5	$3.2	1.27
Job Years	40	5	14	59	1.48
Rest of Washington					
Output	$3.2	$1.3	$1.4	$5.8	1.84
Personal Income	$1.0	$0.4	$0.4	$1.8	1.76
Job Years	21	7	10	38	1.80
Total Washington State					
Output	$9.9	$2.0	$3.0	$14.9	1.50
Personal Income	$3.6	$0.6	$0.9	$5.0	1.41
Job Years	61	12	24	98	1.59

Agriculture Expenditures

The incremental impact of the KDRPP, under historical climate conditions, results in 1,293 additional job-years during the average drought year in the four-county region and a total of 1,351 additional job-years statewide (Table 45). Any given year has a 16.7 percent probability of experiencing a drought. While the majority of impacts are experienced in the agriculture sector, they also accrue in transportation and trade (Table 46).

Table 45 KDRPP Impacts during Drought Year, Marginal to Baseline, Historical Conditions

REGION / IMPACT MEASURE	DIRECT	INDIRECT	INDUCED	TOTAL	MULTIPLIER
Four-County Region					
Output	$99,139,604	$35,089,664	$37,365,977	$171,595,246	1.73
Personal Income	$16,886,013	$16,686,677	$10,463,142	$44,035,832	2.61
Job Years	497	490	305	1,293	2.61
Rest of Washington					
Output	$0	$7,530,230	$4,252,054	$11,782,284	-
Personal Income	$0	$1,303,769	$1,044,547	$2,348,316	-
Job Years	0	34	25	59	-
Total Washington State					
Output	$99,139,604	$42,619,894	$41,618,031	$183,377,530	1.85
Personal Income	$16,886,013	$17,990,446	$11,507,689	$46,384,148	2.75
Job Years	497	524	331	1,351	2.73

Table 46. KDRPP Impacts during Drought Year, 4-County Region, by Industry, Historical Conditions

AGGREGATE INDUSTRY SECTOR	OUTPUT	PERSONAL INCOME	JOB YEARS	AVERAGE WAGE	OUTPUT/JOB YEAR
Agriculture	$110,944,303	$28,983,472	893	$32,634	$124,036
Utilities	$1,426,945	$485,823	10	$48,803	$143,292
Construction	$3,063,769	$1,232,950	21	$58,873	$145,968
Manufacturing	$8,277,910	$625,753	10	$60,079	$783,441
Transportation, Information, Utilities	$34,173,803	$8,810,623	251	$35,028	$135,585
Trade	$8,910,489	$2,940,377	84	$34,773	$105,308
Service	$2,406,137	$788,991	21	$37,487	$113,945
Government	$2,391,891	$167,843	2	$74,101	$1,056,168
Total	$171,595,246	$44,035,832	1,293	$34,061	$132,727

Under adverse climate change conditions, the value of the KDRPP's contributions to water availability in drought years result in 1,223 job years in the four-county region with personal income of $41.7 million (Table 47 and Table 48). Any given year under adverse climate change conditions has a 49.4 percent probability of experiencing a drought. Since Reclamation expects that droughts would be more frequent under climate change, these incremental effects would occur more often than the effects shown in Table 45.

Table 47. KDRPP Impacts during Drought Year, Marginal to Baseline under Adverse Climate Change

REGION / IMPACT MEASURE	DIRECT	INDIRECT	INDUCED	TOTAL	MULTIPLIER
4 County Region					
Output	$93,676,790	$33,130,960	$35,391,382	$162,199,132	1.73
Personal Income	$15,964,642	$15,786,344	$9,910,213	$41,661,199	2.61
Job Years	470	464	289	1,223	2.61
Rest of Washington					
Output	$0	$7,081,187	$4,021,204	$11,102,390	-
Personal Income	$0	$1,228,743	$987,540	$2,216,283	-
Job Years	0	32	24	55	-
Total Washington State					
Output	$93,676,790	$40,212,147	$39,412,585	$173,301,523	1.85
Personal Income	$15,964,642	$17,015,087	$10,897,753	$43,877,481	2.75
Job Years	470	495	313	1,278	2.73

Table 48. KDRPP Impacts, During Drought Year, 4-County Region, by Industry, under Adverse Climate Change

AGGREGATE INDUSTRY SECTOR	OUTPUT	PERSONAL INCOME	JOB YEARS	AVERAGE WAGE	OUTPUT/JOB YEAR
Agriculture	$104,849,930	$27,420,024	844	$32,641	$124,032
Utilities	$1,351,884	$460,288	9	$48,804	$143,290
Construction	$2,893,445	$1,164,829	20	$58,864	$145,934
Manufacturing	$7,815,157	$592,176	10	$60,070	$783,000
Transportation, Information, Utilities	$32,327,013	$8,337,444	238	$35,028	$135,576
Trade	$8,431,512	$2,782,643	80	$34,772	$105,302
Service	$2,271,578	$745,304	20	$37,483	$113,924
Government	$2,258,613	$158,489	2	$74,104	$1,056,207
Total	$162,199,132	$41,661,199	1,223	$34,073	$132,654

Other Expenditures

Other effects of the KDRPP on activities might result in market impacts in more ambiguous ways than these quantified categories of impacts. Therefore, ECONorthwest does not estimate these impacts. If recreational activity declines, so could expenditures and impacts. However, given the availability of substitute opportunities in the four-county region, it is likely that such impacts would be small in terms of the overall regional recreational expenditures. Avoided pumping or acquisition costs for municipal water supply likely involve little change in employment and income. City of Yakima personnel report that the change in groundwater pumping operations with and without a small increase in available surface water would not affect staffing requirements.

3.4 EQ and OSE Analyses

This section shows results of the EQ and OSE Analyses. Because Reclamation would operate the KDRPP the same regardless of which alternative it selects, the scoring results are similar for the two action alternatives. The KDRPP East Shore Pumping Plant Alternative would have a larger footprint and, therefore, has slightly higher construction impacts than the KDRPP South Pumping Plant Alternative.

3.4.1 EQ Analysis Results

Table 49 shows that under the No Action Alternative, conditions for most resources would stay the same or decline. The KDRPP alternatives would cause positive impacts to water supply and bull trout and would increase adaptability to climate change. Under the KDRPP alternatives, most other resources would experience negative impacts, especially reservoir recreation and cultural and archaeological resources.

Figure 17 illustrates that for the EQ resource categories, the KDRPP provides positive impacts for the resources that most directly address the purpose and need of the project -- surface water and bull trout -- while also improving the adaptability to climate change.

Table 49. Comparative Display of Alternatives for EQ Categories

EQ RESOURCE CATEGORY			No Action Alternative		KDRPP East Pumping Plant		KDRPP South Pumping Plant	
		Weight	Significance	Score	Significance	Score	Significance	Score
Surface water	Water supply	0.15	-2	-0.3	2	0.3	2	0.3
	Instream flows	0.15	-1	-0.15	-1	-0.15	-1	-0.15
	Subtotal	0.30		-0.45		0.15		0.15
Bull trout	Food-based prey	0.10	-1	-0.10	1	0.10	1	0.10
	Habitat	0.10	-2	-0.20	2	0.20	2	0.20
	Passage	0.10	-2	-0.20	3	0.30	3	0.30
	Subtotal	0.30		-0.50		0.60		0.60
Fish	Fish abundance	0.02	-2	-0.04	-2	-0.04	-2	-0.04
	Fish passage	0.02	0	0	1	0.02	1	0.02
	Subtotal	0.04		-0.04		-0.02		-0.02
Surface water quality	Reservoir water quality	0.04	0	0	-1	-0.04	-1	-0.04
	Subtotal	0.04		0		-0.04		-0.04
Wildlife	Wildlife	0.04	0	0	1	0.04	1	0.04
	Subtotal	0.04		0		0.04		0.04
Other threatened and endangered species	Northern spotted owl	0.02	0		-1	-0.02	-1	-0.02
	MCR steelhead	0.02	-2	-0.04	-2	-0.04	-2	-0.04
	Subtotal	0.04		-0.04		-0.06		-0.06
Visual quality	Visual quality	0.04	0	0	-2	-0.08	-2	-0.08
	Subtotal	0.04		0		-0.08		-0.08
Land use	Property/easement acquisition	0.04	0	0	-1	-0.04	-1	-0.04

EQ RESOURCE CATEGORY			No Action Alternative		KDRPP East Pumping Plant		KDRPP South Pumping Plant	
		Weight	Significance	Score	Significance	Score	Significance	Score
	Subtotal	0.04		0		-0.04		-0.04
Recreation	Reservoir recreation	0.02	-1	-0.02	-3	-0.06	-3	-0.06
	Changed character of recreation	0.02	0	0	-1	-0.02	-1	-0.02
	Subtotal	0.04		-0.02		-0.08		-0.08
Cultural resources	Cultural and archaeological resources	0.04	0	0	-3	-0.12	-2	-0.08
	Subtotal	0.04		0		-0.12		-0.08
Climate Change	Adaptability to Climate Change	0.04	-2	-0.08	1	0.04	1	0.04
	Subtotal	0.04		-0.08		0.04		0.04
Construction impacts	Construction impacts	0.02	-1	-0.02	-1	-0.02	-1	-0.02
	Transportation	0.02	-2	-0.04	-2	-0.04	-2	-0.04
	Subtotal	0.04		-0.06		-0.06		-0.06
TOTALS		1.00		-1.19		0.33		0.37

Note: Totals and subtotals may not sum exactly due to rounding. MCR steelhead = Mid-Columbia River steelhead.

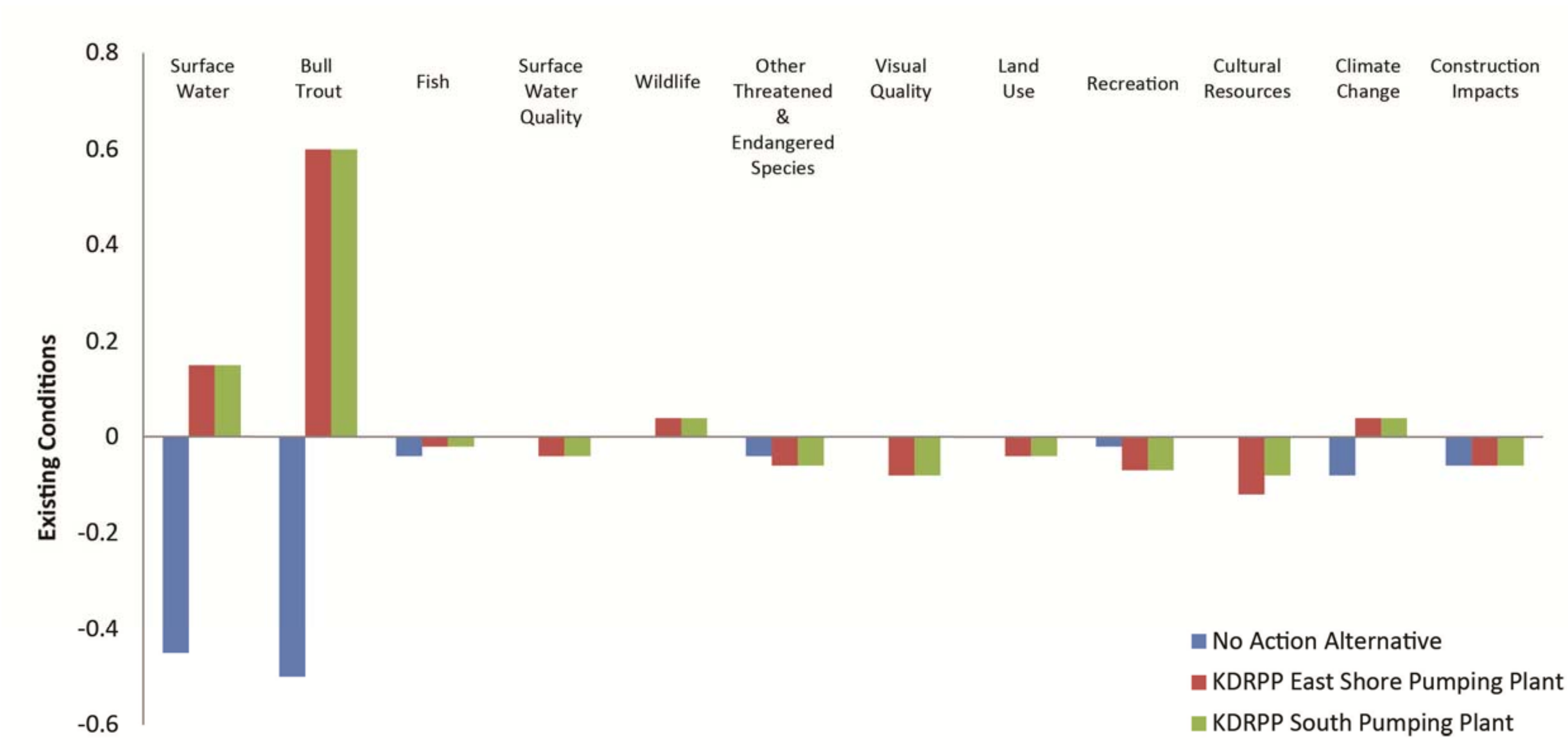


Figure 17. EQ Resource Category Results

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3.4.2 OSE Analysis Results

Table 50 shows that the KDRPP alternatives provide positive impacts to long-term productivity, but minor negative impacts from increased energy use and construction worker impacts. Figure 18 shows that the KDRPP would have minor negative impacts to urban and community structure.

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Table 50. Comparative Display of Alternatives for OSE Categories

OSE RESOURCE CATEGORY			No Action Alternative		KDRPP East Pumping Plant		KDRPP East Pumping Plant	
		Weight	Significance	Score	Significance	Score	Significance	Score
Urban and community impacts	Construction worker impacts	0.15	0	0.00	-1	-0.15	-1	-0.15
	Subtotal	0.15		0.00		-0.15		-0.15
Long-term productivity	Improved fish populations	0.23	0	0.00	0	0.00	0	0.00
	Resilience to climate change	0.23	-2	-0.47	2	0.47	2	0.47
	Improved irrigation reliability	0.23	-2	-0.47	2	0.47	2	0.47
	Subtotal	0.70		-0.93		0.93		0.93
Energy requirements and energy conservation	Increased energy use	0.15	0	0.00	-1	-0.15	-1	-0.15
	Subtotal	0.15		0.00		-0.15		-0.15
Total		1.00		-0.93		0.63		0.63

Note: Totals and subtotals may not sum exactly, due to rounding.

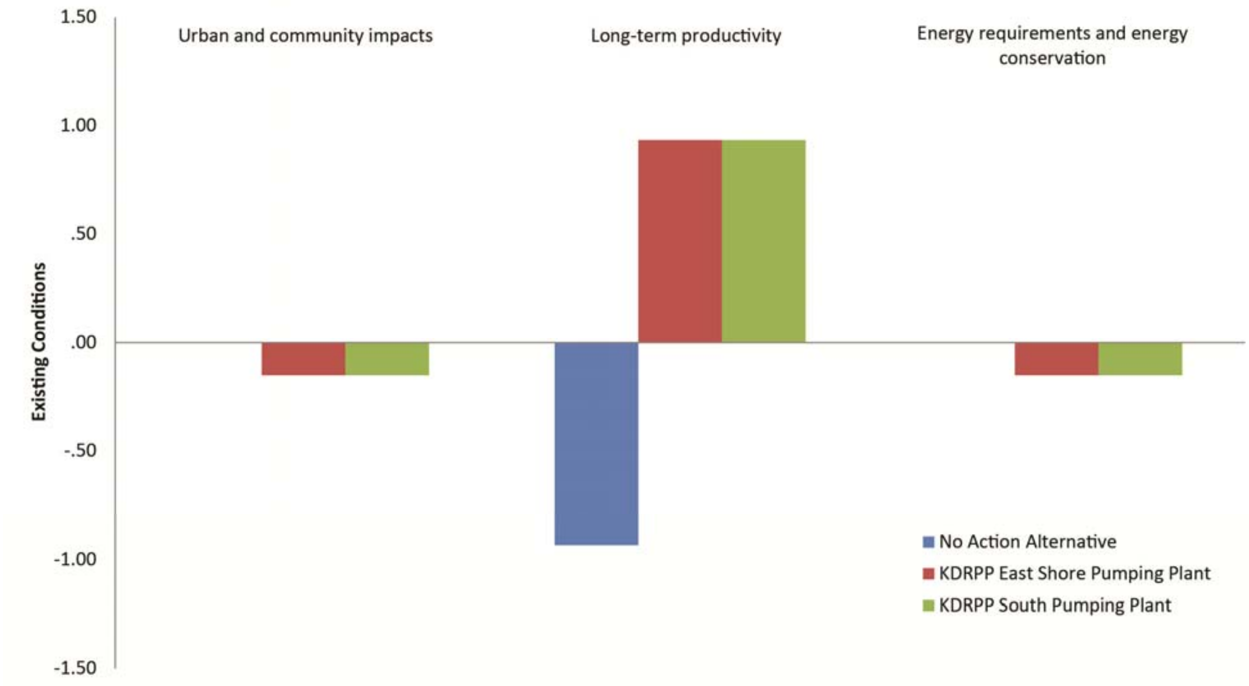

Figure 18. **OSE Resource Category Results**

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